# INDEX.



## APPENDIX.



## DIAGRAMS.

# REPORT

ON THE

# IRRIGATION WORKS OF THE JEYPORE STATE,

# RAJPUTANA.

1. **Report called for.**—This report is prepared in accordance with the orders of Government, conveyed by the Assistant Secretary to the Government of India in the Foreign Department, to the Agent, Governor-General, Rajputana, No. 13 J.R., dated 25th February 1881.

2. **Remarks of Famine Commission.**—In the report of the Famine Commission, part II, chapter V, section II, paras. 72—74, the importance of irrigation is pointed out. It is not supposed that irrigation in Native States is anywhere dealt with in the systematic way in which it is treated by the Imperial Government, and the fact is noticed that the British Government have from time to time lent officers to Native States to superintend their public works; but the Commission are not aware what influence has been exercised to ensure the maintenance of canals and tanks; and suggest that accurate information should be obtained from all Native States as to the condition of their irrigation works, &c.

3. **Jeypore State.**—As regards the Jeypore State, I have been employed here for the last 13½ years; and, as irrigation has been a subject in which I have been deeply interested, I am glad of the opportunity of stating what has been done or is proposed.

4. **Its position geographically.**—The Jeypore State, it should be observed, is situated on the backbone or watershed of India. Part of the drainage runs into the Bay of Bengal eastward; while immediately on our west border the drainage flows westward into the Gulf of Cutch. The general slope of the country is from the north towards the south-east. Situated thus on a ridge with a wide sandy desert tract northwards, it is not to be expected that the same facilities should exist for large canal projects as are found in more favored districts.

5. **Its dependence on local rainfall.**—We have in fact to depend entirely on our rainfall, which, moreover, is very uncertain.

In 1870 it was 40·5 inches, while in 1868 it was only 12·67.

6. **Necessity for storing the rainfall of good years and for large reservoirs.**—This only shews how necessary it is to store all the rainfall possible, so that the bounty of good years may be in hand to make up for the deficiency in bad years.

It shows also how desirable it is to have *large* reservoirs which shall be capable of storing water sufficient for at least two years' consumption.

7. **Wells suggested to supplement small reservoirs.**—Another point which seems desirable, if not necessary, is, in all those places where the reservoirs are not large enough to contain a two years' supply of water, to have a few wells constructed on the fields below. Of course these should not be made without taking into consideration the soil and subsoil, the cost of other wells in the neighbourhood, and the irrigation carried out by

means of them, &c.; but if satisfied on all these points, I believe it would be a great thing to have a few wells below very small reservoir.

It is a known fact that the ground below a tank is affected by the tank, and generally holds more water; and in a dry season, when the reservoir was empty, the cultivator, instead of having to deplore the loss of all his crops for want of water, would be able at all events to work his well and save himself and his cattle.

We have not carried out this policy yet, but it is under consideration. The wells, if built at the expense of the State, would be let out to the cultivators at a nominal rent, and would, on this account, and as an insurance against famine losses, be a certain profit to the State.

8. **Duties of Executive Engineer formerly.**—When I first took up irrigation in this State, it was entirely voluntarily on my part. Roads and buildings only were supposed to be my duties, and my appointment was known as that of the *Sauk Sahib*, or officer in charge of roads.

9. **Policy adopted introducing Irrigation.**—My first aim was to repair existing village tanks. These were generally small works, but this method gave me the opportunity of exploring and so becoming acquainted with the country and its wants. It enabled several works to be rapidly taken up and completed, and enabled me to prove to the Durbar, from the returns realized, that the money entrusted to me was being well laid out, and so gave them confidence gradually to take up larger projects.

10. **Assisted by Mr T. W. Miles.**—I was ably assisted during the years 1873 to 1878 by Mr. T. W. Miles, now Executive Engineer, Kotah and Jhallawar.

11. **Indirect advantages of Irrigation.**—Irrigation had not been thought of for years; and, although the zemindars generally know the value of water, yet it was some time before the Durbar was aroused to understand its value or to see that all the money spent in this State in this way, was not taken from the State; but was only money in circulation; and that the Durbar, by carrying out these works, was not only feeding hundreds of laborers, chiefly their own people, but was also increasing the value of its own property.

12. **Tribute to the memory of H. H. Maharajah Sewaie Ram Sing.**—Although there have been many difficulties to contend with, which is only to be expected in carrying out a new policy in a native State, yet I desire here to pay a just tribute to the memory of H. H. the late Maharajah Sewaie Ram Sing, whose lamented death occurred last September.

He quickly saw the advantages of irrigation, and to his enlightened spirit is greatly due the progress which has been made. In conversation once with me over the map of the State, he pointed to the two largest streams, and said, "these are the life-giving sources."

Thus, by degrees, work was pushed on, and we can now review what has been done

13. **Index Map illustrating progress made.**—An index map is attached, which shews what works have been carried out—90 in all. (See Frontispiece.)

14. **Record of Returns.**—A record has been carefully kept in my office from the beginning, in which the name and cost of every work, as it is completed, is entered, and each year the amount spent on repairs is added.

15. **Rules framed—Zillahdars and Mahafizan appointed.**—To get correct returns rules have been framed, and two native officials, called zillahdars, have been appointed by the Durbar, who have under them on each work a native watchman or mahafiz.

16. **Their duties.**—Each mahafiz has a printed book which he takes daily to the village patel or patwaree, and gets him to enter to whom water has been given and the particulars. These books are checked by the zillahdars on their regular tours of inspection, and are a great help in making up the irrigation returns of the district. These returns are submitted annually to the Durbar, who sends me a copy, and the results are entered in my register against each work. I believe these returns may, therefore, be relied on.

17. **Statement of Returns.**—The statement marked A gives in a tabulated form the result of all this information; it shows for each work the name, contents when full, the number of acres which each will irrigate, the total cost up to August 1880, the amount realized during the past year for water-rate and share of produce, the total amount realized up to date, and the percentage of return for past year on capital invested.

18. **Results.**—It will be seen that 77 works are noted, capable of irrigating about 35,000 acres, allowing 100,000 cubic feet of water per acre, inclusive of absorption and evaporation; and that the total outlay on these works has been Rs. 7,12,868.

Exclusive of pay of zillahdars or mahafizan, the returns for the past year Rs. 80,085, or about 11·23 per cent as profit; and the total income on these works up to date, Rs. 2,25,867—a result which, I think, may be fairly considered very satisfactory. The returns from irrigation since August 1880 are in addition, and have not been yet received.

19. **Table shewing returns in consecutive years.**—The following statement, compiled from the Raj Official Records, will shew the steady progress which has been made in irrigation since 1872, and is encouraging:—

| Year. | Irrigated. Beegahs. | Returns. Amount. Rs. | A. | P. | Remarks. |
|---|---|---|---|---|---|
| 1872 ... ... | ............ | 4,337 | 4 | 9 | |
| 1873 ... ... | ............ | 5,623 | 1 | 6 | |
| 1874 ... ... | ............ | 15,920 | 11 | 9 | |
| 1875 ... ... | 5390·1 ... ... | 6,443 | 4 | 3 | |
| 1876 ... ... | 9833·8 ... ... | 10,649 | 8 | 6 | |
| 1877 ... ... | 17899·5 ... ... | 22,589 | 14 | 0 | |
| 1878 ... ... | 14116·16 ... ... | 22,199 | 13 | 9 | |
| 1879 ... ... | 36045·3 ... ... | 66,814 | 5 | 0 | |
| 1880 ... ... | 49255·15 ... ... | 80,085 | 7 | 3 | |
| | Total ... | 2,34,663 | 6 | 9 | Total amount realized |

20. **Total amount spent by the Raj.**—The amount shown, however, on this statement does not represent all that has been spent on irrigation by the State.

The total up to 31st March 1881 is Rs. 10,98,412, but this includes expenditure on surveys of several works which have either not been yet begun, such as Tori, Boochara, and Ramghur, or only partly done, such as the Bandi Project, from which, therefore, no returns can yet be expected; or which, on completion of the surveys and plans, have been found to be inadvisable either from the great cost, the poor returns anticipated, or some other cause. It should be observed also that some of these works are not yet in full working order, for it takes at least four or five years before full returns on a work can be expected.

21. **Lawa.**—It may be interesting to allude to Lawa, a small district attached to the Jeypore Political Agency. Two tanks have been made here—the second one has only been lately finished, but the first cost Rs. 4,399, and in four years has realized Rs. 1,515, giving an average annual return of 8·60 per cent on the outlay.

22. **Value of irrigation tested.**—In order to test practically the value of irrigation I had some experiments carried out.

Three beegahs were taken at Mora Sagar close together—the ground is good stiff soil; one beegah was watered three times, the second beegah was watered once only, and the third not at all. The results are as follows :—

| Description. | Quantity of Wheat produced. | | | Proceeds of Yield. | | |
|---|---|---|---|---|---|---|
| | Maunds. | Srs. | Cht. | Rs. | As. | P. |
| 1.—One Beegah watered three times ... ... | 5 | 22 | 12 | 16 | 1 | 6 |
| 2.—Ditto watered only once ... ... ... | 0 | 7 | 12 | 0 | 9 | 0 |
| 3.—17·5 biswa not watered at all ... ... | 0 | 2 | 12 | 0 | 3 | 6 |
| | | | | 16 | 14 | 0 |
| | Bhoosa ... | | | 0 | 4 | 0 |
| | | | | 17 | 2 | 0 |

The outlay incurred was as follows :—

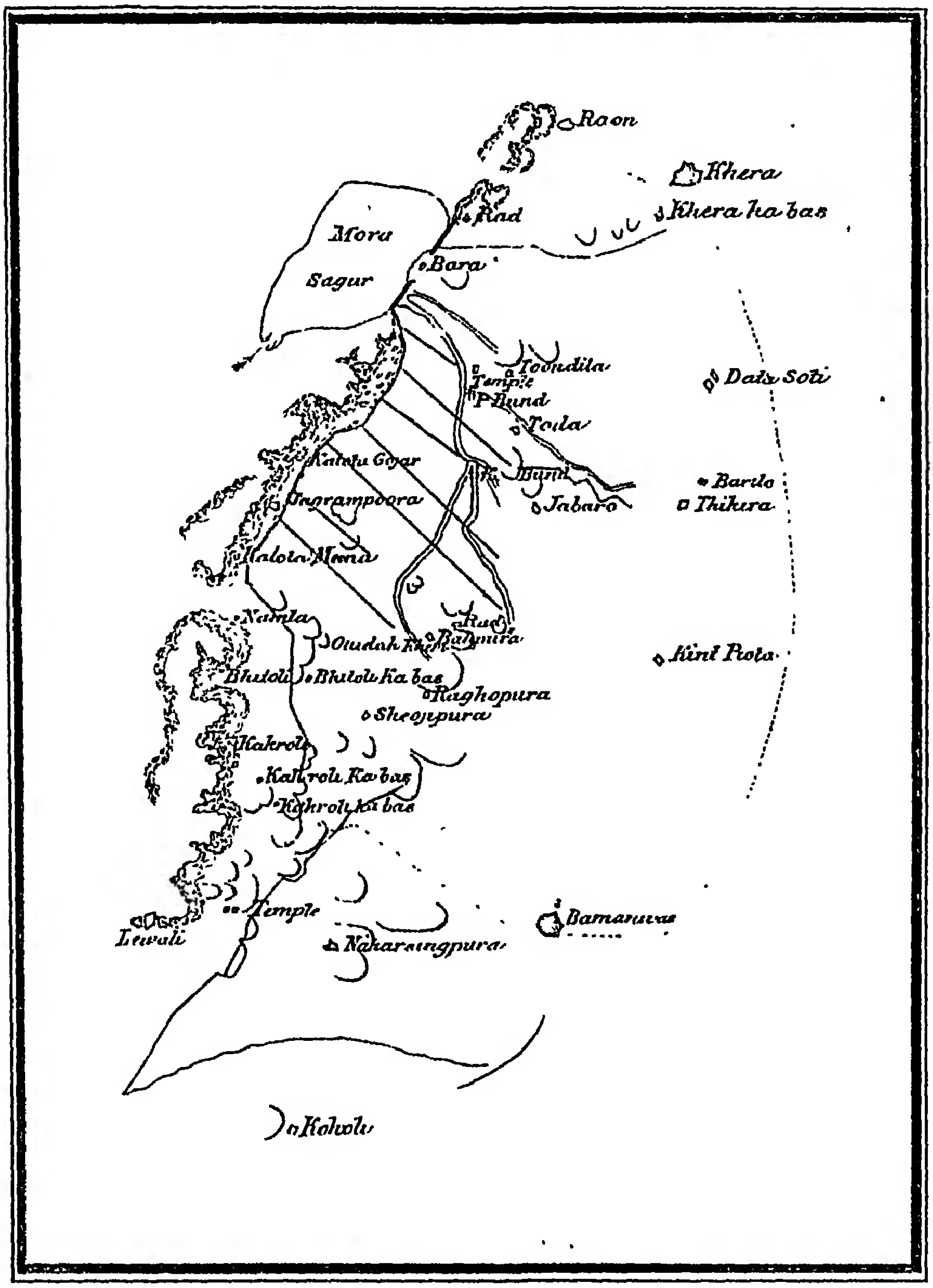
| | Rs | As. | P. |
|---|---|---|---|
| Ploughing three beegahs ... ... ... ... ... | 1 | 6 | 0 |
| Twenty-eight seers Wheat for seed-sowing ... ... ... ... | 2 | 0 | 0 |
| Cutting ... ... ... ... ... ... | 0 | 9 | 0 |
| Guarding ... ... ... ... ... ... | 0 | 11 | 0 |
| Raj Land Tax ... ... ... ... ... ... | 5 | 12 | 0 |
| Watering two beegahs as above ... ... ... ... ... | 1 | 0 | 0 |
| Harvesting and winnowing, &c. ... ... ... ... ... | 1 | 0 | 0 |
| Total ... | 12 | 6 | 0 |

23. **Yield and outlay compared.**—In order, however, to come to a fair conclusion, we ought to take the expenditure and returns on the one beegah only, which was watered three times. It is as follows :—

| Particulars. | Md | Sr. | Ch. | Yield. Rs. | As. | P. | Outlay. Rs. | As. | P. |
|---|---|---|---|---|---|---|---|---|---|
| Yield, Wheat ... ... ... | 5 | 22 | 12 | 16 | 1 | 6 | ... | ... | ... |
| Bhoosa ... ... ... ... | 4 | 30 | 0 | 0 | 4 | 0 | ... | ... | ... |
| Ploughing ... ... ... | | | ... | ... | ... | ... | 0 | 7 | 4 |
| Nine seers Wheat for seed ... ... | | | ... | ... | ... | ... | 0 | 10 | 8 |
| Cutting ... ... ... ... | | | ... | ... | ... | ... | 0 | 3 | 0 |
| Guarding ... ... ... | | | ... | ... | ... | ... | 0 | 3 | 8 |
| Raj Land Tax ... ... ... | | | ... | ... | ... | ... | 1 | 14 | 8 |
| Watering ... ... ... | | | ... | ... | ... | ... | 0 | 8 | 0 |
| Harvesting, winnowing, &c. ... ... | | | ... | ... | ... | ... | 0 | 5 | 4 |
| Total | | | ... | 16 | 5 | 6 | 4 | 4 | 8 |
| Profit | | | ... | ... | ... | ... | 12 | 0 | 10 |
| | | | | 16 | 5 | 6 | 16 | 5 | 6 |

78740

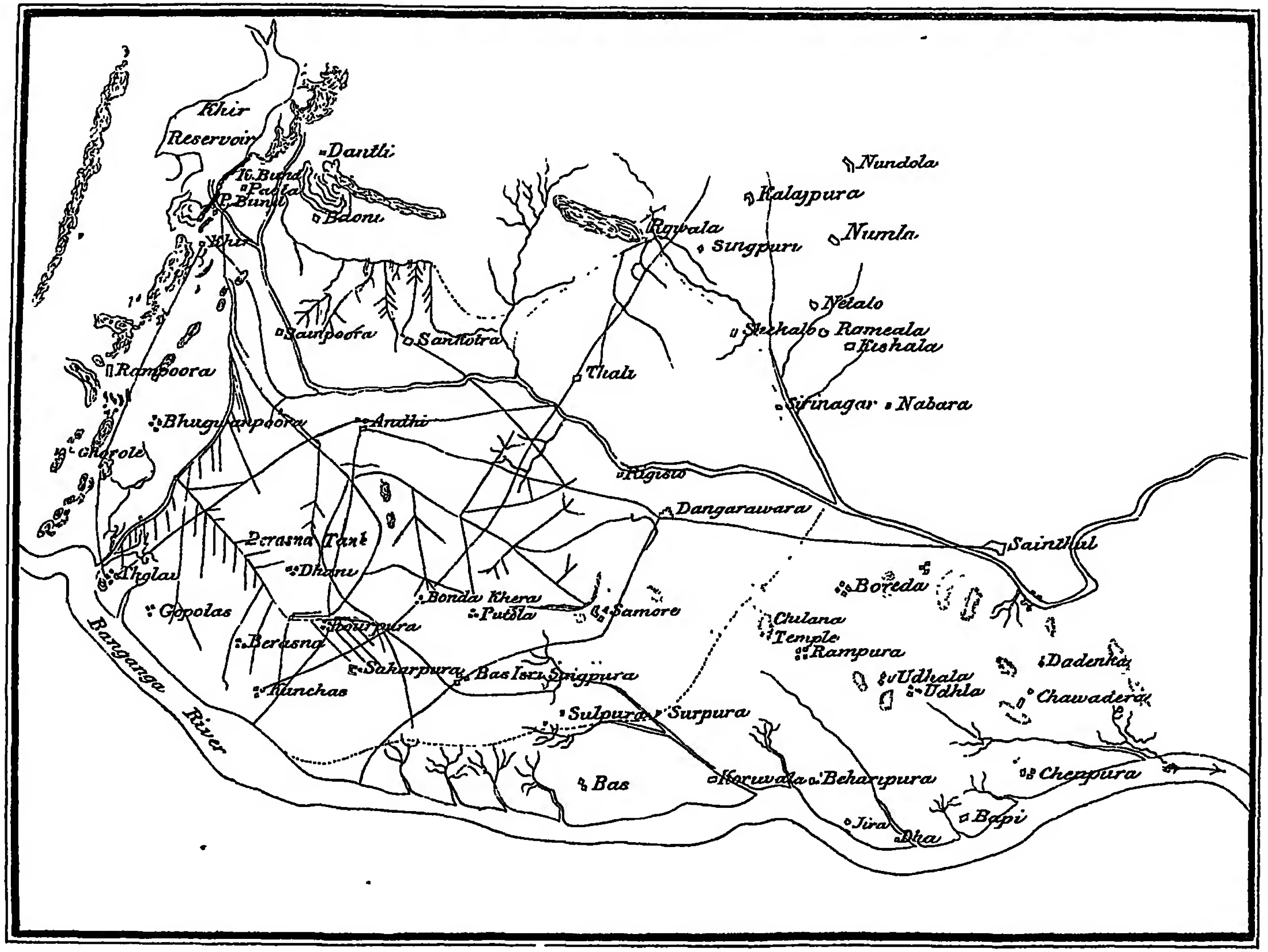
Mora Sagur Irrigation Project
Scale 2 Miles = 1 Inch.




Calcutta Central Press

## Khur Irrigation Project

Scale 2 Miles 1 Inch



24. **Conclusions.**—The above facts prove that here good ordinary soil with three waterings will yield a profit of Rs. 12 per beegah, or say Rs. 36 per acre. It also proves that the same land, if not watered or watered only once, will not yield a profit.

The whole of the profit, therefore, about Rs. 12, is entirely due to water, for which the Raj only charge 8 annas a beegah. It is clear a much higher water-rate might be charged, and yet leave a handsome profit to the cultivator. It shows also the necessity for a good supply of water.

The water-rate is only 8 annas a beegah, or about Rs. 1-8 per acre. The Raj take in addition the share of the produce, generally about one-third.

25. **Necessity for a good and sure supply of water.**—One element of success in irrigation is, however, to ensure annually to the cultivator sufficient water for his crop. It is here that all small tanks fail. At the very time they are most required, perhaps, they are perfectly dry.

26. **Examples of large reservoirs.**—It is with the hope of meeting this objection that wells have been suggested, and that I have lately brought forward much larger projects than were at first attempted.

As examples of two which have been lately constructed, I attach the ground plans of Khirr and Mora Sagar.

*Khirr.*—Cost Rs. 1,01,848; contains, when full, 479 millions cubic feet; is capable of irrigating 4,793 acres; and has a system of distributary channels of 75 miles in total length. It was finished in 1878, and the returns up to August 1880 are Rs. 14,437, that is for two years' irrigation only. Average annual return $\frac{1}{14}$th on the outlay. *7 per cent*

*Mora Sagar.*—Cost Rs. 93,209; contains, when full, 456 millions cubic feet; is capable of irrigating 4,564 acres; and has a total length of 35 miles of distributary channels which supply 20 villages. It was finished in 1878, and the returns up to August 1880 are Rs. 34,932, that is for two years' irrigation only. The overflow from the waste weir, if any, fills the tanks below. Average annual return $\frac{3}{16}$th on the outlay. *i.e. 18·7 per cent*

The above will show what irrigation works have been done in the Jeypore State since I came here.

27. **Projects proposed.**—As I have been invited to note any other points of interest, and the Famine Commission ask for information as to the possibility of the extension of irrigation (para. 74, Famine Commission Report), I may be permitted, perhaps, to say a few words on some of the irrigation projects which have been lately prepared:—

1.—The Bandi Project.
2.— „ Ramghur „ on the River Bangunga.
3.— „ Tori „
4.— „ Boochara „

28. **How prepared and recorded—Examples.**—Printed reports on 1, 3 and 4 are attached, and will show the way in which such schemes are prepared and put on permanent record for the benefit of the State.

29. **The Bandi Project.**—The Bandi Project, I am happy to say, is nearly completed. The masonry weir in the river for diverting the water into the canal and the head works have just been built, and 15 miles of the main, and 13½ miles of distributaries, have been completed.

The earthen dam, which will impound 30 feet depth of water, will be finished in three months. This will form a reservoir four miles in length, containing 578 millions cubic feet, covering an area of 2·4 square miles, and after allowing ¼ as lost (a liberal allowance) by absorption and evaporation, it ought to be sufficient to irrigate 4,340 acres annually.

This reservoir ought to fill with only $4\frac{1}{2}$ inches of rainfall, and as the drainage of about 227 square miles falls into it, it ought to fill with certainty every year, and in most years should overflow. Any water which overflowed would not be allowed to go to waste, but would be caught by the weir some distance below the site of the dam, and be taken by the canal to fill the village tanks situated at each side along its course.

This is a good instance of how all the water of a large stream may be utilised—storing what is possible in reservoirs, and leading off the surplus to replenish village tanks.

30. **The Ramghur Project.**—Regarding the Bangunga, a project has been prepared for constructing a masonry dam on this river at a place near Ramghur. The dam would be 150 feet in height with the object of catching every drop of water available, and because no suitable waste weir is possible at a lower level. It would be capable of storing 22,000 millions cubic feet, and if it ever filled, the length of the highest contour all round would be 40 miles. Although this might never be obtained yet every drop of water would be caught and could be utilised, as the whole country south-east for many miles is commanded by it.

Allowing 8 inches of rainfall to run off the drainage area of 320 square miles we should have 5,947 millions cubic feet of water stored every year; and if a quarter of this was considered as lost by evaporation and absorption, there would remain 4,460 millions cubic feet.

The estimate for this work is fourteen lacs. The plans and site have been inspected by Colonel Rundall, the Chief Engineer for Irrigation to the Government of India, and were approved.

Rs. 26,495 were spent on preliminary surveys and preparations, and the work was on the point of being begun—the contract in fact was given—when the Bhurtpore Durbar represented that if the work was carried out it would diminish the level of the flood in the river as it passed through the Bhurtpore State, and that Jeypore should not be allowed to build the dam, or should compensate Bhurtpore for any loss which might accrüe.

Jeypore, on the other hand, points out that this is not a question of running water, but of *floods*, of which Bhurtpore only takes a little, and allows millions of tons to go to waste; and argues, I think justly, that every State is entitled to a fair share of its own floods. Considering that the river has a drainage area of 1,450 square miles before it reaches the Bhurtpore border, of which only 312 square miles would be interrupted by this dam, and the rainfall of about 1,130 square miles allowed to pass on; and that Jeypore would not be taking more than from its position it is entitled to receive, and ought not to be held liable even if any difference did occur (which is most improbable) in the height of the floods 50 miles away. The Bhurtpore border is 50 miles distant below the site of the proposed dam.

This is not the place to enter into a history of this subject nor to recapitulate all the arguments which have taken place. The matter has been already before the Government of India; but, as I brought the project forward in the first instance, I am interested in it, and adduce it as a substantial proof of the efforts which I have made to promote irrigation in this State; and it is a matter of sincere regret that any State should be prevented from carrying out a large work of this nature from the fears of another State—fears which, I believe, to be as groundless as they are unjustifiable, and that in consequence millions of tons of life-giving water should pass away from a land needing water, to be wasted in the ocean. As the matter stands at present the Imperial Government sees no objection to Jeypore building the dam subject to compensation for any loss which may be proved, while Jeypore wishes the Imperial Government to decide what share of this river it is entitled to. It will then take up the project, only intercepting that portion, and on the understanding that it is not held liable for any compensation for doing so, as it has reason to believe that groundless claims for compensation would be advanced, which would only lead to complications and dissatisfaction.

31. **The Tori Project.**—The Tori Project briefly stated is as follows:—A nullah, known as the Sohodra River, which rises in the Ajmere District, passes through the Jeypore State, and, joining the Mashi River, falls into the Bannas opposite Tonk.

A favourable site for bunding up the stream is found near Malpoora, where the entire drainage of 320 square miles passes over a rocky bed. The stream in flood has a discharge here of 50,201 cubic feet per second, the whole of which now goes to waste.

A dam, partly of masonry and partly of earth with a masonry corewall, would be required for a total length of 6,600 feet, with a maximum height of 50 feet. The greatest depth of water would be 40 feet, the reservoir would be 6½ square miles in area, and would contain 1,753 millions cubic feet, sufficient to irrigate about 17,530 acres. Next to the famous Dhabur Lake, it would be the largest artificial reservoir in Rajputana.

The estimate is Rs. 5,34,750. Of the area commanded, 37 square miles are in the Jeypore State, and 36 in the adjoining State of Tonk. It is not, however, thickly populated.

I hope some day this work may be carried out. The report on this project which is attached gives full details on all points.

32. **The Boochara Project.**—The drainage of 80 square miles of country passes through a rocky gorge near Boochara, a village 50 miles north of Jeypore and 30 south-east of Khetree.

The masonry dam would be 472 feet in length at the top and 85 feet maximum height, and would form a reservoir 1¾ square miles in area, and would contain 1,328 millions cubic feet of water, more than sufficient to irrigate the whole of the Kot Putli district, belonging to Khetree, 70 square miles in area, which lies below it.

The estimate is Rs. 3,21,345.

The subject is under consideration of the Durbar.

The printed Report attached gives full particulars.

33. **Area which could be irrigated by proposed Projects.**—If these four projects are carried out, and the reservoirs filled properly, we should have in addition to the amount of water stored on the Statement marked A (which, it has been shewn, is capable of irrigating about 35,000 acres) the following:—

| | Quantity of water, cubic feet. | Capable of irrigating acres. |
|---|---|---|
| Bandi Project ... ... | ... 578 millions. | 4,340 |
| Boochara " ... ... | ... 1,329 " | 13,290 |
| Tori " ... ... | ... 1,753 " | 17,530 |
| Ramghur " ... ... | ... 4,460 " | 44,600 |
| TOTAL ... | ... 8,120 " | 79,760 acres |

that is, about 8,120 millions cubic-feet of water capable of irrigating about 80,000 acres.

34. **Conclusion.**—The Statement, marked B, attached shews what the total expenditure by the State has been during my service here.

Sent as I was to the Jeypore State by the Government of India in 1867 to assist the State in its Public Works, I trust this Report will shew that the confidence in me has not been misplaced, and that the subject of Irrigation especially has been prosecuted with the energy and success it deserves, and that I have done my best to urge on the Durbar the importance of irrigation, so prominently alluded to by the Famine Commissioners in para. 74 of their Report.

S. S. JACOB, MAJOR,

*Executive Engineer, Jeypore.*

# A.

*STATEMENT showing the result of Irrigation in the Jeypore State since 1867.*

| Names of Tanks. | Capacity when full. | Capable of irrigating acres allowing 100,000 per acre for both crops. | Total cost to end of August 1880. Rs. As. P. | Amount realized from 1st September 1879 to 31st August 1880. Rs. As. P. | Total Revenue up to 31st August 1880. Rs. As. P. | Percentage. | Remarks. |
|---|---|---|---|---|---|---|---|
| Bhao Sagar ... ... ... ... | 85,158,718 | 851·58 | ......... | ......... | ......... | ...... | |
| Maota, Ram Sagar and Maun Sagar ... ... | 8,679,200 | 86·79 | 26,833 3 11 | 1,800 6 0 | 11,002 6 9 | 6·71 | |
| Khoe Nagoree Tank ... ... ... | 3,713,260 | 37·13 | 2,040 6 0 | 19 4 0 | 57 5 6 | 0·94 | |
| Bund Koonthara .. ... ... ... | 69,676,200 | 696·76 | 9,088 5 10 | 7 1 6 | 103 15 9 | 0·08 | |
| " Chundlaie ... ... ... ... | 41,500,000 | 415·00 | 9,430 6 10 | 2,755 6 0 | 11,052 4 9 | 29·22 | |
| " Naota and Nahur ... .. ... | 174,720,600 | 1747·20 | 62,834 12 1 | 2 8 0 | 4,079 13 9 | 0·004 | |
| Nahur Chundlaie ... ... .. ... | ......... | ............ | 16,594 13 11 | 1,081 8 3 | 4,885 5 3 | 24·59 | |
| " Bangunga ... ... ... ... | ......... | 2000·00 | 34,873 11 11 | 737 10 6 | 2,445 9 0 | 2·97 | |
| Bund Beerasna ... ... ... ... | 147,150,000 | 1471·50 | 11,500 15 6 | 423 12 0 | 1,432 3 0 | 3·68 | |
| " Rayawalla ... ... ... ... | 85,719,000 | 857·19 | 15,892 11 1 | 574 0 6 | 3,442 12 3 | 3·61 | |
| " Rysur ... ... ... ... | 479,359,375 | 4793·59 | 1,01,548 6 1 | 2,789 11 3 | 14,437 12 9 | 8·63 | |
| Nahur Kapriawas ... ... ... ... | ......... | 400·00 | 4,599 14 9 | 2,726 9 3 | 12,870 10 3 | 60·56 | |
| Talao Jetpura ... ... ... ... | ......... | ............ | 5,128 15 9 | 671 6 6 | 1,736 0 3 | 13·09 | |
| " Bandolao ... ... ... ... | 38,560,000 | 385·60 | 3,228 3 9 | 96 7 0 | 96 7 0 | 2·97 | |
| " Bhaosa ... ... ... ... | 17,569,000 | 175·69 | 1,490 1 0 | 115 6 6 | 140 6 9 | 7·71 | |
| Bund Dobolao ... ... ... ... | 87,943,525 | 879·43 | 19,142 3 10 | 82 8 0 | 3,897 15 6 | 0·43 | |
| Kala Talao ... ... .. ... | 8,875,620 | 88·75 | 1,516 15 1 | ......... | 1,055 9 9 | ...... | |
| Bhorey ka Daud, Mozabad ... ... ... | 4,765,100 | 47·65 | 1,051 7 11 | 116 15 0 | 721 6 6 | 13·98 | |
| Nyzragur " ... ... ... | 82,636,000 | 826·36 | 8,640 5 11 | 1,141 7 0 | 16,359 0 6 | 17·92 | |
| Bijey Sagar Rainwall ... ... ... | 22,810,000 | 228·10 | 4,837 3 1 | 981 9 0 | 1,643 3 6 | 20·29 | |
| Bankia Talao, Cheroo ... ... ... | 15,060,650 | 150·60 | 2,781 2 9 | 1,056 8 9 | 3,419 5 0 | 38·00 | |
| Ram Sagar " ... ... ... | 42,185,000 | 421·85 | 2,259 8 9 | 107 15 3 | 107 15 3 | 4·78 | |
| Bund Kagia ... .. ... ... | 5,394,000 | 53·94 | 2,739 2 9 | 83 3 9 | 112 14 3 | 3·03 | |
| " Madhorajpura ... ... ... | 15,521,250 | 155·21 | 4,655 7 0 | 408 0 0 | 1,962 12 3 | 8·76 | |
| Kanolao, Phagee ... ... ... ... | 17,580,000 | 175·80 | 4,926 7 9 | 717 9 6 | 1,592 6 9 | 14·63 | |
| Ram Sagar " ... ... ... ... | 23,800,000 | 238·00 | 2,925 6 7 | 538 1 9 | 2,000 10 9 | 18·52 | |
| Boojulee and Bhugtolao, Phagee ... ... | 17,100,000 | 171·00 | 3,857 12 7 | 670 0 3 | 2,820 0 9 | 17·38 | |
| Teelalao, Phagee ... ... ... ... | 36,160,000 | 361·60 | 7,155 10 8 | 1,376 13 0 | 2,880 13 0 | 19·24 | |
| Tank Gunwur ... ... ... ... | 73,208,000 | 732·08 | 21,648 13 1 | 2,786 0 3 | 4,274 12 3 | 12·86 | |
| " Bhamolao ... ... ... ... | 9,681,600 | 96·81 | 1,191 3 3 | 440 10 0 | 630 10 6 | 31·67 | |
| Ram Sagar Lamba ... ... ... | 56,823,000 | 568·23 | 16,841 5 9 | 1,513 4 6 | 2,271 0 0 | 8·98 | |
| Tank Nasreeda ... ... ... ... | 17,868,740 | 178·68 | 10,944 6 6 | 1,380 11 3 | 3,732 10 3 | 13·74 | |
| " Shub Daud Ganetee ... ... ... ... | 5,977,225 | 59·77 | 1,322 12 9 | 471 10 3 | 499 0 9 | 35·65 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| ,, Khedolao ... ... ... ... | 10,015,800 | 100·15 | 2,528 6 8 | 146 14 9 | 250 5 9 | 5·80 |
| ,, Gongolao ... ... ... ... | 17,055,750 | 170·55 | 4,242 7 6 | 41 15 6 | 48 12 3 | 0·99 |
| ,, Karoria Toda Ray Sing ... ... ... | 4,593,298 | 45·93 | 2,731 0 9 | 270 14 3 | 739 5 9 | 9·92 |
| ,, Rathoria ,, ... ... ... | 12,113,475 | 121·13 | 1,674 14 6 | 444 2 9 | 1,302 9 0 | 26·50 |
| ,, Borara ,, ... ... ... | 4,957,400 | 49·57 | 2,540 15 7 | 70 2 0 | 83 0 6 | 2·75 |
| ,, Saitibas ,, ... ... ... | 6,352,500 | 63·52 | 4,961 15 8 | 272 14 0 | 464 3 0 | 5·50 |
| ,, Sandla ... ... ... ... | 25,271,500 | 252·71 | 3,781 15 11 | 357 10 0 | 463 10 0 | 9·46 |
| ,, Morla Sree, Ramnagar ... ... ... | 6,620,000 | 66·20 | 2,589 0 7 | 91 11 3 | 434 8 0 | 3·54 |
| ,, Bala Sagar, Kakurwara ... ... ... | 4,035,000 | 40·35 | 892 8 8 | 355 13 6 | 403 6 9 | 39·87 |
| ,, Beebolao, Basguntee ... ... ... | 5,400,000 | 54·00 | 1,770 0 11 | ........ | 364 10 9 | ...... |
| ,, Daugurthul, Chaksoo ... ... ... | 13,500,000 | 135·00 | 6,306 6 7 | 1,292 10 0 | 2,946 1 6 | 20·48 |
| ,, Rawutwalla ,, ... ... ... | 52,927,416 | 529·27 | 5,919 12 8 | 712 6 6 | 2,767 11 0 | ...... |
| ,, Lambia ,, ... ... ... | ........ | ........ | 15 0 0 | 1,065 15 0 | 1,060 15 0 | 29·96 |
| ,, Gaitolao Dosa ,, ... ... ... | ........ | ........ | 2,218 14 0 | 474 10 6 | 2,520 3 3 | 21·37 |
| ,, Namolao Barra ,, ... ... ... | ........ | ........ | 1,118 10 7 | 55 0 0 | 262 5 6 | 4·91 |
| ,, ,, Chota ,, ... ... ... | 12,337,000 | 123·37 | 261 15 6 | 13 0 0 | 257 0 0 | 4·96 |
| ,, Beejey Sagar Buswa ... ... ... | 10,812,990 | 108·12 | 5,172 8 3 | 270 0 0 | 292 0 9 | 5·23 |
| Koond Mora ... ... ... ... | ........ | ........ | 408 0 0 | 635 13 0 | 1,691 14 6 | ...... |
| Mora Sagar ... ... ... ... | 456,454,735 | 4564·54 | 93,209 15 8 | 16,452 6 3 | 34,932 10 0 | 17·65 |
| Bund Kote ... ... ... ... | 21,351,180 | 213·51 | 4,591 15 6 | 81 4 0 | 85 0 0 | 1·76 |
| Futteh Sagar, Taisgawn ... ... ... <br> Tank Maheswa ... ... ... ... | 146,460,237 | 1464·60 | 25,597 9 10 | 3,214 15 9 | 6,050 12 6 | 12·56 |
| ,, Hoorla ... ... ... ... | ........ | ........ | ........ | ........ | ........ | ...... |
| Bund Nahur Khora ... ... ... | 6,500,000 | 65·00 | 4,408 9 0 | 82 0 3 | 266 3 9 | 1·83 |
| Tank Saleempoor ... ... ... ... | 11,009,075 | 110·09 | 1,953 0 5 | 4 2 0 | 509 15 9 | 0·21 |
| ,, Seecundurpoor ... ... ... | 26,650,505 | 226·50 | 7,378 1 5 | 214 1 3 | 214 1 3 | 2·90 |
| ,, Julsein ... ... ... ... | ........ | ........ | 4,096 2 0 | 22 11 3 | 973 9 3 | 0·55 |
| ,, Jatwalla ... ... ... ... | 7,262,085 | 72·62 | 1,129 14 0 | 504 14 3 | 1,396 12 6 | 44·69 |
| Bishen Samund, Ghat Bhandari ... ... | 440,000,000 | 4400·00 | 13,089 6 3 | 1,049 1 3 | 1,198 7 3 | 8·01 |
| Tailonwalla, Wuzeerpore ... ... ... | 20,560,995 | 205·60 | 2,043 3 7 | 665 14 0 | 2,105 4 0 | 32·59 |
| Ram Talao ,, ... ... ... | 2,536,063 | 25·36 | 1,330 0 0 | 359 8 9 | 476 2 9 | 27·03 |
| Barra Talao ,, ... ... ... | 2,532,065 | 25·32 | 1,394 0 9 | 187 3 9 | 301 8 3 | 11·19 |
| Tank Niwazwalla ... ... ... ... | 1,836,450 | 18·36 | 17 8 3 | 219 13 6 | 463 13 0 | ...... |
| Bund Sarolee ... ... ... ... | 31,109,024 | 311·09 | 9,212 15 4 | 123 14 6 | 772 9 9 | 1·34 |
| Motee Sagar ... ... ... ... | 121,555,900 | 1215·55 | 12,766 12 10 | 132 0 3 | 835 2 0 | 1·03 |
| Tank Jeolee ... ... ... ... | 6,791,900 | 67·91 | 774 10 6 | 164 8 0 | 419 6 6 | 21·23 |
| ,, Mirzapore ... ... ... ... | ........ | ........ | 1,570 4 11 | 479 15 0 | 1,298 13 6 | 30·56 |
| ,, Nazimwalla ... ... ... ... | 32,678,400 | 32·67 | 6,327 8 0 | 1,829 0 0 | 4,192 8 0 | 28·90 |
| Bund Beenoree and Irrigation Cut to Bhadurwalla, Bamniawas ... ... ... ... | ........ | ........ | 33,137 8 0 | 6,482 8 9 | 27,903 15 9 | 19·56 |
| Ram Sagar, Chore Malarna ... ... ... | 49,678,000 | 496·78 | 9,820 15 10 | 466 4 3 | 1,309 9 3 | 9·08 |
| Delra ,, ... ... ... | 10,935,598 | 109·35 | ........ | 314 6 0 | 314 6 0 | |
| Doorga Sagar ,, ... ... ... | 7,142,540 | 71·42 | 6,801 5 6 | 728 4 6 | 5,709 2 0 | |
| Dhoond ,, ... ... ... | 8,634,745 | 86·34 | ........ | ........ | ........ | |
| Total ... | ........ | 35086 36 | 7,12,868 10 5 | 80,085 7 3 | 2,25,867 12 9 | 11·23 |

## B.

*STATEMENT of Expenditure on Public Works, Jeypore State, since 1867 to 31st March 1881.*

| | Amount. | | |
|---|---|---|---|
| | Rs. | As. | P. |
| Original Works ... ... ... ... | 18,65,339 | 6 | 7 |
| Repairs ... ... ... ... ... | 6,56,354 | 1 | 1 |
| Irrigation Works ... ... ... ... | 10,98,412 | 4 | 8 |
| Miscellaneous Public Improvements ... ... | 10,87,640 | 13 | 4 |
| Establishment ... ... ... ... | 2,54,756 | 4 | 10 |
| Miscellaneous Items ... ... ... ... | 6,913 | 4 | 2 |
| Other State Works, ... ... ... ... | 38,508 | 8 | 0 |
| GRAND TOTAL Rs. ... | 50,07,924 | 10 | 8 |

S. S. JACOB, MAJOR,

*Executive Engineer, Jeypore.*

# PUBLIC WORKS DEPARTMENT,

## JEYPORE STATE.

## REPORT

ON THE

# BANDI IRRIGATION PROJECT.

A. Acton: Calcutta Central Press Co., Ld., 5, Council House Street.

# INDEX.

## INTRODUCTION.



## THE WEIR.



## THE CANAL.



## THE RESERVOIR.

## REVENUE.

# PUBLIC WORKS DEPARTMENT,

## JEYPORE STATE.

## REPORT

ON THE

# BANDI RIVER IRRIGATION PROJECT.

**Description of the River.**

1. The Bandi rises in the hills about 30 miles north of the city of Jeypore, near Samodh (see Index Map). It flows generally in a south-west direction, but as it approaches the hill of Kalegh, its course is due west, diverted by a spur of the Kalegh hill, round the foot of which it turns, and then takes a direction due south.

About 50 miles further on it joins the Mashi River, which falls into the River Chambul near the town of Tonk.

The Bandi appears first as a perennial stream, about 20 miles above Kalegh, near the village of Tantiawas; but the flow is small and a few miles below Kalegh, owing probably, to the sandy bed, the stream disappears altogether.

**Limited use made of the water.**

2. Small kutcha bunds are put annually across the bed of the Bandi after the rains are over, where there is any water available, and it is utilised for irrigation, but to a very limited extent.

**Flood waters lost to the State.**

3. No advantage, however, is taken of the flood waters, nor of the increased flow after the rains, for three or four months, all which water is entirely lost to the Jeypore State.

**District needing water.**

4. A reference to the Index Map will show a large tract of country about 320 square miles, situated on the west of the Bandi between it and the Mashi. The whole of this is first class soil, and, if properly irrigated, might be most profitable to the Jeypore State. At present

thousands of acres are uncultivated, chiefly for want of water.

**Tanks which might be filled every year.**

5. During the last ten years we have carried out ten Tank Irrigation projects in this district, near Mozabad, Phaggi, Choroo, and Madhorajpoora; in years of ordinary rainfall, the tanks all fill and are quite sufficient to prove that irrigation does pay, but in years of scanty rainfall these tanks do not fill up properly.

There are also four or five other sites for good talaos.

**The wants of the District, and means of meeting them contrasted.**

6. We have then on the one hand a district of about 320 square miles wanting water, ten large tanks with an aggregate capacity of about 280 millions cubic feet ready to be filled every year; also sites where other tanks can be made; and on the other hand a large River, like the Bandi, every year carrying away to the sea tons of water in flood and after floods, of which as yet no advantage whatever is taken.

The project under consideration is intended to store as much as possible of the waters of the Bandi now lost to the State—to ensure these tanks being filled every year, and by giving one or two or more waterings to increase cultivation in the whole district.

**Method proposed.**

**Weir and Canal.**

7. It is proposed to do this by,—

*a.*—Constructing a masonry weir across the Bandi below the Railway Bridge near Asalpore and taking a canal from it.

**Storage Reservoir.**

*b.*—Constructing a storage reservoir at Kalegh, about 7 miles above the proposed weir.

**Object of Weir and Canal.**

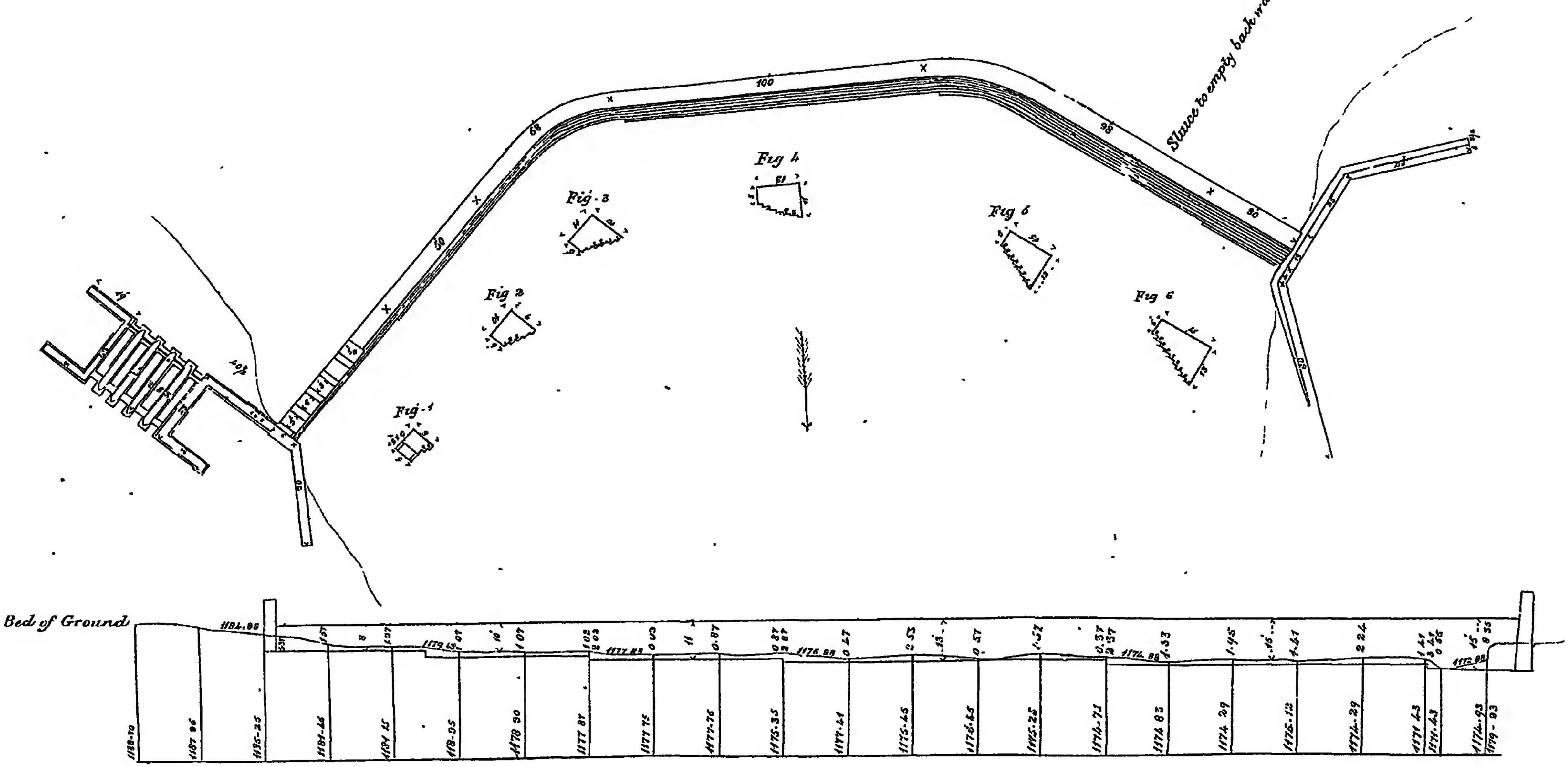
8. The weir would divert a portion of the flood waters and all the water after floods, and convey them by the canal to the district and tanks needing water.

**Object of Storage Reservoir.**

9. While the storage reservoir at Kalegh would prevent heavy floods from going to waste, and would be a reservoir which could be utilised to replenish the canal when the natural stream ceased to flow.

# BANDI RIVER IRRIGATION PROJECT

*Proposed Masonry Weir*




*Scale 40 feet=1 inch*

## THE WEIR.

**The Weir.**

10. The site proposed is 400 feet, south of (*i.e.*, below) the State Railway Bridge over the Bandi.

The banks here are well defined, the soil is rock, and there is a ledge of rock across the bed of the river, which will form a good foundation and serve as an apron.

The site is in every way well adapted for a masonry weir.

**Ground Plan.**

11. The ground plan (see Diagram) is on a curve adapted to the rock in the bed of the river, and the wings are taken well into the rock at each end.

**Section.**

12. The proposed section is shown in the Figures 1 to 6; the up-stream face is vertical; the down-stream side is broken into a series of steps of 1 foot tread and 2 feet fall, which will be of solid stone roughly dressed square. The height is 15 feet above the bed of the river in the lowest point; the thickness at top is 5 feet and at the bottom 13 feet. The foundation course will be dove-tailed into the natural rock, the surface of which will be cut to receive it.

When the water stands at the level of the top of the weir there will be 11 feet of water at the masonry piers of the Railway Bridge. The level of the Rails will be 22 feet above the level of the water. A sluice will be provided in the weir in order to empty the back water when necessary.

The area drained by the Bandi at this point is about 240 square miles.

The slope of the bed of the river at the site of the weir is 7 feet per mile.

The sectional area of highest flood is about 2,227 square feet, and its greatest height as shown by the villagers 7½ feet.

**Discharge over Weir.**

13. The length of the weir will be 386 feet. It will pass off 25,000 cubic feet per second in heavy floods running 7 feet deep, which, however, are not likely to occur after the storage reservoir at Kalegh has been constructed.

**Sluices to supply Canal.**

14. The sluices to regulate the supply to the canal will be placed at the west end of the anicut, and will be founded on rock.

They will consist of four arched openings, each $4' \times 4'$ closed by vertical wooden shutters sliding in cut-stone grooved pillars, to admit the water at pleasure and keep the flood under control.

The shutters will be raised and lowered by means of a chain and vertical wheel, or by a vertical rod with screwed head working in a transom bar.

The sill of the Canal Sluice would be 3 feet *below the top of the weir; 12 feet above the* bed of the river.

**Scouring Sluices.**

15. Scouring sluices to keep the head of the canal free from silt will be put at the west end of the weir near the head of the canal.

There is a capital place for them, with good solid rock for the foundations and surface discharge.

**Method to increase flow down canal if necessary after floods.**

16. In an inundation or flood canal it is a great point to be able to take off as much water as possible while the flood lasts. With this view, therefore, provision will be made to enable planks, each 5 feet long and 1 foot high, to be erected on the top of the weir throughout its whole length.

These planks will be each let into cut-stone pillars (grooved) 5 feet apart from centre to centre, and can be put up one by one after the heaviest floods are past, and the water would then stand 4 feet above the sill of canal, and would keep the canal well supplied as long as the river flows and enable an immense quantity of water to be taken off for storage.

## THE CANAL.

**Canal.**

17. The canal is taken off the right or west bank. Its bottom width is 15 feet, with side slopes 1 to 1; the slope of the bed is 2 feet per canal mile of 5,000 feet.

**Discharge.**

18. It will discharge as follows with water running:—

| Feet. | | C. ft. | |
|---|---|---|---|
| 1 | deep | 28 | per second. |
| 2 | „ | 80 | „ „ |
| 3 | „ | 150·6 | „ „ |
| 4 | „ | 238· | „ „ |

Between the Head-works and Ugras village, for a distance of about 2 miles, the excavation

is heavy, the greatest depth being 29 feet; but the natural surface is soon gained, and after that, with the exception of a ridge near Mokumpoora at mile 9, there is no heavy cutting.

A longitudinal section of the canal is shown on the Diagram opposite.

The canal has been taken in about 4 feet excavation wherever it is possible to do so, and as far from the river as is consistent with this condition.

**Corewalls to be built across the Nullahs.**

19. There are a few nullahs to cross between the Head-works and near Ugras;—for all these places, and wherever there is any uncertainty as to leakage, corewalls are to be built right across; the foundations to be stepped well into the solid ground on each side and carried down to such a depth as will ensure little or no leakage.

These corewalls will be of masonry, 2 feet thick, and will be backed with earth on both sides well rammed, and will be carried up in the line of the embankment 6 feet above the bed of the canal.

**Cross drainage intercepted.**

20. All the drainage from the land above the canal on the west side will thus be intercepted by the canal, and the flood waters will be taken off to fill the tanks at Mozabad, Phaggi, Choroo, &c., previously alluded to.

In dealing with large rivers or where there are heavy floods in the cross drainage it would not be safe to do this, but the drainage area here intercepted is small, and the rainfall not heavy. The sandy nature of the soil too would absorb a good portion of the fall, and water is so valuable that it is advisable to catch all that is to be had.

**Advantages of Corewalls.**

21. The fact of damming all these nullahs near Ugras ought in fact to be of great benefit to that village, instead of allowing the rain, as hitherto, to rush off to join the Bandi, cutting away the land as it goes; each nullah will be closed, the progress of the flood will be stopped, and silt will be deposited, so as in time to raise the level of what is now the nullah bed, to the same level as the bed of the canal, and the excess of the flood will be passed on down the canal.

**Escape for surplus water.**

22. It is necessary, however, to be prepared to provide for the safe flow-off of all the cross drainage which will thus be caught by the canal; for this purpose it is proposed to make a large escape near the Ugras village at 5 miles.

The canal bed here is on the natural surface of the ground, so, instead of banking it in across this low ground, it is proposed to make a masonry wall three feet high for a length of 300 ft. on one side only, the left hand or east side; on the top of this wall self-acting shutters will be added, increasing the height one foot more.

When 4 feet of water comes down the canal, these shutters will swing open horizontally and allow the extra flood above 3 feet to escape over the top of the wall on to a masonry floor. As the flood falls, they will be closed, and the canal will run full.

Sluices will be provided in this masonry escape wall to allow of a tank belonging to Ugras situated below the canal being filled, and also to allow of a scour out of any silt which may be deposited in the bed of the canal.

**Excavated Earth.**

23. The excavated earth will be deposited so as to allow everywhere a clear roadway of 15 feet on each side of the canal. In certain places where the canal passes low ground the embankment will be constructed on the low side only so as to receive the surface drainage and carry it on for storage.

**Iron troughs provided.**

24. Wherever the irrigation channels from wells have been intersected by the canal, sheet iron troughs, supported on light iron trusses, will be provided to carry the well water across.

**Masonry Bridge at mile 10.**

25. A small bridge will be necessary at mile 10, where the canal intersects the Ajmere Road to carry the road across it.

**Falls.**

26. One fall of 1 foot is necessary at mile 14.

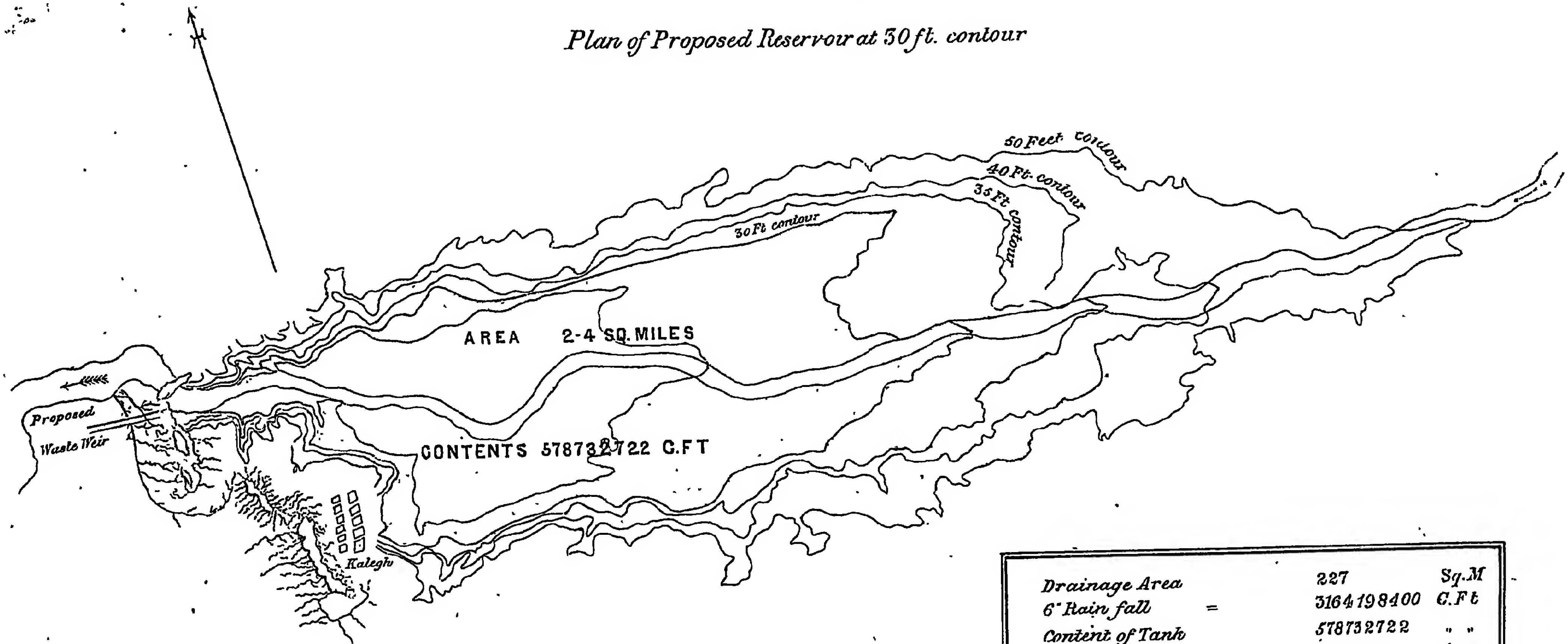
**Irrigation from the Canal.**

27. Irrigation eastward direct from the canal can be begun between miles 4 and 5, all the land between it and the river being below the bed of the canal.

Irrigation westward can begin between miles 10 and 11, where the ground towards Mozabad is also below the level of the bed of the canal.

# BANDI IRRIGATION PROJECT.

*Plan of Proposed Reservoir at 30 ft. contour*




*Scale 3,000 feet = 1 inch.*

| | | | |
|---|---|---|---|
| Drainage Area | | 227 | Sq. M |
| 6" Rain fall | = | 3164198400 | C. F t |
| Content of Tank | | 578732722 | " " |
| Area | | 1547·66 | Acre |
| Mean depth | | 8·58 | Ft. |
| Estimated amount Rs. | | 81000 | |
| Water stored per Rupee | | 7145 | C Ft. |

**Extension of Canal up to 35 miles.**

28. At mile 13, about 2 miles above the village of Kishenpura, the canal passes on to the watershed of the district, and from this point onwards the canal might be extended up to 35 miles, and water for irrigation might be taken off on both sides of the canal the whole way.

**Distance of the present Canal.**

29. At present it is proposed to take the canal only as far as Kishenpura, 15 miles.

**Road Crossings.**

30. For the present all village road crossings will be merely sloped off.

**Benefit derived from Canal and Weir.**

31. The time that this canal will prove of use is during the floods and for about 3 months afterwards. During this period no kutcha bunds could stand, and all the water in the river goes to waste. On the construction of the weir and canal most of it will be taken off for irrigation.

**Will not be complete without Storage Reservoir.**

32. As soon, however, as the zemindars erect their kutcha bunds, or the river ceases to flow, the canal will of course be quite dry. It is to meet this want that the second part of the project is proposed, *viz.*, the construction of a "Storage Reservoir at Kalegh," and until this is carried out, proper returns from the canal must not be expected.

---

## THE KALEGH RESERVOIR.

**Site of the Reservoir.**

33. Near the village of Kalegh is a large natural jheel. The greater portion of it is at present "Khar" or salt land, uncultivated and useless. At the 30 feet contour out of 1,547 acres only 426 are cultivated.

**Site selected for the dam.**

The Bandi River flows through this low ground and about a mile north-west of Kalegh; at the hamlet of Mora, the jheel is so contracted that there is only a gorge by which the water escapes, and the course of the river is considerably diverted by a rocky spur which juts out into the river. It is at this point that it is proposed to construct the dam to impound the flood waters of the Bandi.

**Highest water line.**

34. Contours have been taken up to 50 feet, and there is no other outlet for the flood than the gorge which it is proposed to dam up; but as anything above 30 feet would submerge the village of Kalegh, and a good deal of cultivable land round the margin of the jheel as well, it

has been decided to take 30 ft. as the greatest depth to be stored.

**Land that will be submerged when the water stands at 30 feet contour.**

35. At this contour 1,278 beegahs of land would be submerged which are at present cultivated ; but all this land is on the margin, and would soon be again available as the water receded.

The Bandi River has a drainage area of 220 square miles at this point.

**Contents, area and mean depth of the reservoir at 30 feet contour.**

36. The contents of the proposed reservoir at 30 feet would be 578,732,722 cubic feet, say 578 millions cubic feet ; and the area would be 2·4 square miles, or 1,547 acres ; the mean depth would be 8·58 feet. The slope of the bed here is 7 feet per mile, so that the water would extend up the jheel for about 4 miles with an average width of about half a mile.

**Rainfall of the surrounding district.**

37. The average rainfall in these parts is 24 inches, and supposing only $\frac{1}{4}$th of this was stored, in ordinary years, there would still be enough to fill the reservoir 5·3 times over.*

**Rainfall required to fill the Reservoir.**

38. The calculations at the foot of this page will show that a rainfall of $4\frac{1}{2}$ inches, allowing only $\frac{1}{4}$ of it as stored, would be enough to fill the reservoir.

**Probable amount of water to spare after filling Reservoir.**

39. The above calculations will show that not only ought the reservoir to be easily filled, but that with a *run-off* the *drainage* area of six inches, besides filling the reservoir there would be about (3,066—578)=2,488 millions cubic feet, which would pass down the river.

Much of this, however, would be intercepted by the weir and be taken off by the canal.

**Details of the Dam.**

40. The Diagram opposite shows a longitudinal section across the gorge at the site of the dam.

Good soil is plentiful and close at hand ; so it is proposed to close the gorge with an earthen

---

* Inches of rainfall × 3,630 = cubic feet per acre ∴ 6" × 3630 = 21780 cubic feet per acre.
220 square miles × 640 acres × 21780 = 3066624000 cubic feet = say 3,066 millions.

$\frac{3066}{578} = 5·3$ contents of reservoir.

To find the quantity of rainfall run off required to fill the reservoir—

Rainfall sq. miles acres

X. × 3630 × 220 × 640 = 578732722 (contents of reservoir.)

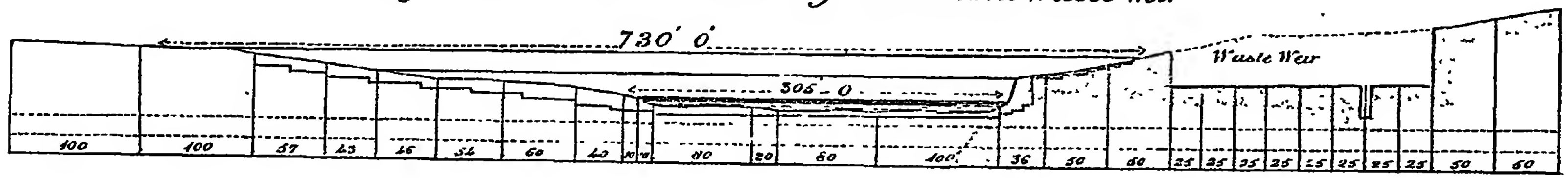
$X = \frac{578732722}{3630 \times 220 \times 640} = 1·13$ inches.

If $\frac{1}{4}$ is assumed as run off then $1·13 \times 4 = 4·5$.

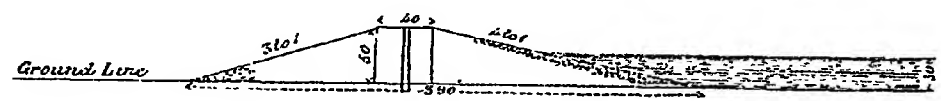
4·5 inches actual fall of rain will be sufficient to fill the reservoir, allowing only $\frac{1}{4}$ as actually run off.

# BANDI IRRIGATION PROJECT

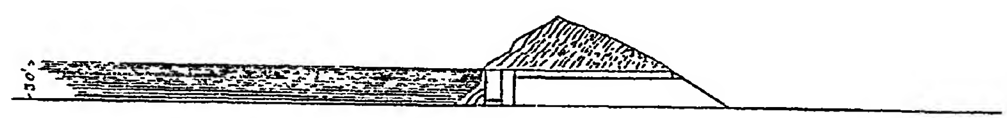
*Longitudinal Section on line of Bund and waste weir*




*Section of Bund shewing core wall*




*Section through waste weir on line of sluice*



*Scale 150 feet = 1 inch.*

bund strengthened by a masonry corewall, and to cut a waste weir out of the solid rock in the spur on the south bank.

The earthen dam has been taken 40 feet thick at top with an inner slope of 4 to 1 and an outer slope of 3 to 1, purposely far in excess of what is necessary to resist the pressure of the water.

The greatest length at the bottom is 305 feet, and at the top 790 feet. The height will be 50 feet—20 feet above the high water line.

The inner slope would be pitched with dry stone, 1 foot thick on a layer 4½″ thick of broken stone to prevent guttering of the surface below.

**Corewall.**

41. The corewall will be stepped into the rock at the end of the spur, and be carried across the river bed well into the solid ground on the north bank. The foundations will be on rectangular masonry wells sunk 10 feet deep into the bed of the river. It is not expected that leakage under this bund will be entirely stopped, but the toe of the outer slope will be protected with a few courses of dry stone to prevent weeping of the bank and to allow the water to escape clear.

All leakage will flow down the river bed as usual 7 miles, and be there caught by the masonry weir described in the first part of the project and be taken off by the canal.

**Waste Weir.**

42. The waste weir will be cut out of the solid rock. Of the section at one end the greatest height is 28 feet and greatest width 100 feet, and of the section at the other end of the excavation the greatest height is 54 feet and greatest width 176 feet; the length is 200 feet, and will entail a total excavation of 631,024 cubic feet rock. All this stone, however, will be utilised in the masonry of the corewall and for the pitching of the face of the dam.

The water might flow any depth over this solid rock without any fear of damage.

If it stood 10 feet deep the weir would be discharging 22,200 cubic feet per second, which is more than will probably ever occur, as the weir can only act after the reservoir has been filled, and the large area of the reservoir, 2¼

square miles, would naturally prevent any great increase in the rise.

As the dam is unavoidably at an angle to the waste weir spur, the waste weir has been fixed so as to clear the inner slope of the dam, and masses of excavated rock will be spread over it so as to prevent any scour of the inner face of the dam as the water rushes past it over the waste weir.

**Sluices how provided.**

43. For the sluices the following arrangement is proposed:—A cut 10 feet wide will be made right through the solid rock of the waste weir, 30 feet deep, entailing 55,875 cubic feet rock cutting. A wall will afterwards be built across it, and in this will be securely fixed 5 sluices, each 2 feet in diameter, each capable of discharging with 1 foot head about 16 cubic feet per second.

The sluices will be raised or lowered by means of vertical iron rods with screwed heads.

**Advantages of silt deposited.**

44. It is more than probable that a good deal of silt will be brought down in flood and deposited over the "khar" land in the bed of the jheel or reservoir, and as the water recedes, this fine alluvial deposit ought to prove of great benefit and yield luxuriant crops.

**Cost of Reservoir.**

45. The estimate for this reservoir is Rs. 81,000.

**Value of water stored.**

46. The value, therefore, of the water stored is 7,145 cubic feet per rupee, which is exceptionally good; in most irrigation projects it is generally about half this amount.

**Cost of storing one million cubic feet.**

47. The cost of storing one million cubic feet is 140 rupees.*

48. The estimates and all other details are to be seen in the office of the Executive Engineer, Jeypore; the abstract only need be noted here.

---

* $\frac{\text{Estimate } 81{,}000}{\text{Contents } 578} = 140$ Rs. per million cubic feet.

## Abstract of Estimate.

| | | Rs. | Rs. |
|---|---|---|---|
| WEIR— | | | |
| Masonry Weir ... ... ... | ... | 21,858 | |
| Total cost of Weir | ... | | 21,858 |
| CANAL— | | | |
| Head works ... ... ... | ... | 3,617 | |
| Masonry works ... ... ... | ... | 25,501 | |
| Earth work up to 15 miles ... .. | ... | 51,390 | |
| Ditto ditto 15 „ to 35 miles ... | ... | 43,670 | |
| Total cost of Canal | ... | | 1,24,178 |
| RESERVOIR— | | | |
| Dam ... ... ... ... | ... | 42,846 | |
| Excavation rock for waste Weir ... | ... | 27,765 | |
| Sluices ... ... ... .. | ... | 10,013 | |
| Total cost of Reservoir | ... | | 80,624 |
| Grand Total of Project | ... | ... ... | 2,26,660 |

*Estimate of Bandi River Project.*

## Abstract.

### First 15 Miles Canal.

| Name of Work. | Quantity. | Items. | Rate. | | | Per | Amount | Total. |
|---|---|---|---|---|---|---|---|---|
| Weir of River ... | 13,863 c. ft. | Cutting rock in Foundation ... | 5 | 0 | 0 | 100 c. ft | 693·15 | |
| | 1,287 „ | Cut stone coping for top of weir ... | 2 | 8 | 0 | 10 „ | 3218 00 | |
| | 25 r. ft | Jhiri Stone for scouring sluices ... | 1 | 8 | 0 | 1 r. ft. | 37·00 | |
| | 1,594 c. ft. | Cut stone steps of outside of weir... | 2 | 8 | 0 | 1 c. ft | 3985·00 | |
| | 48,036 „ | Pucka masonry work of do. ... | 20 | 0 | 0 | 100 c. ft. | 9607·20 | |
| | 165 s. ft | Wooden shutters of scouring Sluices ... ... ... | 2 | 0 | 0 | 1 s ft. | 330·00 | |
| | | For pitching and embankment on both ends of weir ... ... | ... | ... | .. | ...... | 2000·00 | |
| | | | | | | | 19870·35 | |
| | | Contingencies ... ... | 10 | 0 | 0 | 100 Rs. | 1987·03 | 21,858 |
| Regulating Bridge | 3,142 c ft | Foundation Masonry .. ... | 20 | 0 | 0 | 100 c. ft | 428·40 | |
| | 5,217 „ | Superstructure do. ... ... | 40 | 0 | 0 | „ | 2086·80 | |
| | 1,033 „ | Arches do. ... ... | 40 | 0 | 0 | „ | 413 20 | |
| | 60 r. ft. | Jhiri Stones ... ... | 1 | 8 | 0 | 1 r. ft | 90 00 | |
| | 135 s. ft. | Wooden shutters ... ... | 2 | 0 | 0 | 1 s. ft | 270·00 | |
| | | | | | | | 3288·40 | |
| | | Contingencies ... ... | 10 | 0 | 0 | 100 Rs. | 328·84 | 3,617 |
| Escape near Ugras at south | 9,121 c ft. | Pucka Rubble Masonry ... | 16 | 0 | 0 | 100 c ft | 1459·36 | |
| | 50 no. | Cut Stone Pillars ... ... | 3 | 0 | 0 | 1-no | 150·00 | |
| | 355 s. ft. | Wooden shutters ... ... | 2 | 0 | 0 | 1 s. ft | 710·00 | |
| | 100 no. | Iron Nails ... ... ... | 0 | 12 | 0 | 1 no. | 75·00 | |
| | 36 r. ft | Jhiri cut stones ... ... | 1 | 0 | 0 | 1 r. ft. | 36·00 | |
| | 3,888 s. ft. | Pitching stones ... ... | 7 | 0 | 0 | 100 s. ft | 272·16 | |
| | 641 „ | Cut stone coping ... ... | 1 | 8 | 0 | 1 „ | 961·50 | |
| | | | | | | | 3664·02 | |
| | | Contingencies ... ... | 10 | 0 | 0 | 100 Rs | 366 40 | 4,030 |
| Corewalls of Nullas, &c. ... | 4,655 c. ft | P. Masonry Corewall, Nulla No. 1... | 14 | 0 | 0 | 100 c ft | 651 70 | |
| | 6,420 „ | Do. do. do. 2... | 14 | 0 | 0 | „ | 898 80 | |
| | 18,240 „ | Do. do. do. 3... | 14 | 0 | 0 | „ | 2553 60 | |
| | 1,403 „ | Do. do. do. 4... | 14 | 0 | 0 | „ | 196·42 | |
| | 3,100 „ | Do do. do. 5 | 14 | 0 | 0 | „ | 434·00 | |
| | 5,600 „ | Do. do. do. 6... | 14 | 0 | 0 | „ | 784·00 | |
| | 17,900 „ | Do. do. do. 7... | 14 | 0 | 0 | „ | 2506·00 | |
| | 20,221 „ | Do. do. do. 8... | 14 | 0 | 0 | „ | 2830 94 | |
| | 35,040 „ | Corewall between pegs No. 133 and 171 ... ... | 14 | 0 | 0 | „ | 4905·60 | |
| | | | | | | | 15761 06 | |
| | | Contingencies ... ... | 10 | 0 | 0 | 100 Rs. | 1576·11 | |
| | | For digging Foundation ... | ... | ... | | ...... | 620 00 | 17,957 |
| Field water inlets | 5,982 c. ft | Pucka Masonry for No. 6 ... | 16 | 0 | 0 | 100 c. ft | 957·12 | |
| | | Contingencies ... ... | 10 | 0 | 0 | 100 Rs. | 95·71 | 1,053 |
| Ajmere Road Bridge ... | 7,992 c. ft. | Pucka Rubble Masonry ... | 14 | 0 | 0 | 100 c. ft | 1118·88 | |
| | 1,640 „ | Arches do. .. | 30 | 0 | 0 | „ | 492·00 | |
| | 4,269 s. ft. | Pucka Plaster ... ... | 4 | 0 | 0 | 100 s. ft | 170·76 | |
| | | | | | | | 1781 64 | |
| | | Contingencies ... ... | 10 | 0 | 0 | 100 Rs. | 178·16 | 1,960 |
| Fall ... | 1,577 c. ft. | Pucka Rubble Masonry ... | 20 | 0 | 0 | 100 c. ft | 315·40 | |
| | 70 s. ft. | Cut stone coping ... ... | 2 | 0 | 0 | 1 s. ft. | 140·00 | |
| | | | | | | | 455·40 | |
| | | Contingencies ... ... | 10 | 0 | 0 | 100 Rs | 45·54 | 501 |
| | | Carried forward Rs. ... | ... | . | ... | ...... | ...... | 50,976 |

*Estimate of Bandi River Project.*—(Contd.)

## Abstract.

### First 15 miles Canal.

| Name of Work | Quantity. | Items. | Rate. Rs. | A. | P. | Per. | Amount. | Total. | |
|---|---|---|---|---|---|---|---|---|---|
| | | Brought forward ... | ... | ... | ... | ...... | ...... | ... | 50,976 |
| Canal ... | 15032810 c. ft. | Earth-work of Canal ... | 3 | 0 | 0 | 1000 c ft. | 45098·43 | | |
| | 540000 " | Ditto " Branch to Mozabad Sagor. | 3 | 0 | 0 | 1000 " | 1620·00 | | |
| | | | | | | | 46718·43 | | |
| | | Contingencies ... ... | 10 | 0 | 0 | 100 Rs. | 4671 84 | 51,390 | |
| | | Total rupees of first 15 miles Canal Works. | ... | . | . | ...... | .. ... | ... | 102366 |
| | | From 16 up to 35 Miles— | | | | | | | |
| Canal ... | 10000000 " | Earth-work of Canal ... | 3 | 0 | 0 | 1000 c ft. | 30000 00 | | |
| | | Rupees for Branches ... | ... | . | . | ...... | 7000 00 | | |
| | | | | | | | 37700 00 | | |
| | | Contingencies ... .. | 10 | 0 | 0 | 100 Rs. | 3770·00 | 40,700 | |
| Falls ... | No. 6 | Falls No 6 ... ... | 450 | 0 | 0 | 1 Fall | 2700 00 | | |
| | | Contingencies ... ... | 10 | 0 | 0 | 100 Rs. | 270·00 | 2,970 | |
| | | Total rupees of F. 15 up to 35 miles Canal Works. | ... | | .. | ...... | ...... | ... | 43,670 |
| | | Reservoir— | | | | | | | |
| Dam ... | 4377872 c. ft | Earth-work of Embankment | 6 | 0 | 0 | 1000 c. ft | 26267·23 | | |
| | 600000 " | Ditto of water passage F. Waste Weir up to edge of river. | 3 | 0 | 0 | 1000 " | 1800·00 | | |
| | 64249 s. ft | Pitching stones of inner slope | 2 | 0 | 0 | 100 s ft | 1284·98 | | |
| | 2631 c. ft | Concrete in foundation of Corewall. | 9 | 0 | 0 | 100 c ft. | 236 79 | | |
| | 98021 " | Pucka Rubble Masonry Core-wall. | 12 | 0 | 0 | 100 " | 9362·52 | | |
| | | | | | | | 38951 52 | | |
| | | Contingencies ... ... | 10 | 0 | 0 | 100 Rs | 3895·15 | 42,846 | |
| WasteWeir | 631024 " | Cutting Hill ... ... | 4 | 0 | 0 | 100 c ft | 25240·96 | | |
| | | Contingencies ... ... | 10 | 0 | 0 | 100 Rs. | 2524·09 | 27,765 | |
| Sluices ... | 55875 " | Cutting Hill for sluice passage | 6 | 0 | 0 | 100 c ft. | 3352·50 | | |
| | 7000 " | Masonry of cross wall " | 25 | 0 | 0 | 100 " | 1750·00 | | |
| | 4 no. | Iron sluices ... ... | 1,000 | 0 | 0 | Each | 4000·00 | | |
| | | | | | | | 9102·50 | | |
| | | Contingencies ... ... | 10 | 0 | 0 | 100 Rs. | 910·25 | 10,013 | |
| | | Total Rupees of Reservoir Works. | ... | .. | ... | ...... | ...... | ... | 80,624 |
| | | Grand Total Rupees ... | ... | ... | ... | ...... | .. ... | ... | 226660 |

## REVENUE.

**Cost of Weir and Canal.**

49. The total cost of weir, canal and storage reservoir is Rs. 2,26,660.

It is difficult to state precisely what the returns from the weir and canal alone will be, as so much will depend upon the seasons.

In years of scanty rainfall the value of water will be inestimable, and there never is a year in which the river does not flow more or less; and in a famine year this canal may be the saving of the crops under its influence.

However putting the floods aside, we know from experience of the river that it will run for at least three months after the rains; and with leakage of the reservoir above it, very likely it would continue longer. It is generally flowing for six months, but I do not wish to overstate the case. Assuming that the canal will flow only 1 foot deep for three months, it would represent a discharge of about 217 millions cubic feet.*

**Calculations of Returns.**

50. Allowing 100,000 cubic feet as sufficient for 1 acre, this would be sufficient for 2,170 acres.

| | | Rs. |
|---|---|---|
| 2,170 acres @ Rs. 1-8 per acre for water rate ... ... | = | 3,255 |
| Enhancement of revenue Rs. 5 per acre ... ... | = | 10,850 |
| Total Rs. | ... | 14,105 |
| *Deduct*— | | |
| For maintenance @ 1 per acre | = | 2,170 |
| Net Return ... | Rs. | 11,935 |

**Percentage expected from Canal.**

51. This would give a return of 8·17† per cent. on the canal and weir expenditure alone.

Again, from actual observation, we find that the water flowing down the river on the 1st October 1879 was 13 cubic feet per second. Allowing 1 cubic foot per second as sufficient to irrigate 200 acres, we should have 2,600 acres as irrigated, which agrees closely with the calculation above; to be on the safe side, let us

---

* The canal at 1 foot deep will discharge 80 cubic feet per second, and in 3 months this would represent—

| Quantity. | Months. | Days. | Hours. | Minutes. | Seconds | |
|---|---|---|---|---|---|---|
| 28 × | 3 × | 30 × | 24 × | 60 × | 60 | =217,728,000 cubic feet water, or say 217 millions. |

† Cost of weir. Cost of canal.

21858 + 124178 = 146036

146036 : 100 :: 11935 : x.

∴ x = 8 17.

take only 2,000 acres, then the returns would be as follows :—

| | | Rs. |
|---|---|---|
| 2,000 acres water-rate @ 1-8 per acre | = | 3,000 |
| Enhancement of revenue, Rs. 5 per acre ... ... | = | 10,000 |
| Total Rs. | ... | 13,000 |
| *Deduct*— | | |
| For maintenance Re. 1 per acre | = | 2,000 |
| Net Return ... | = | 11,000 |

This would give a profit of 7·53* per cent. on the outlay for canal and weir.

If the Kalegh reservoir was made, the flow of course would be more.

**Expenditure including cost of Reservoir.**

52. If the reservoir is taken also into consideration the total expenditure will be Rs. 2,26,660.

**Probable Returns on the total outlay.**

53. Allowing $\frac{1}{4}$ of the contents of the reservoir to be lost by absorption and evaporation, a liberal allowance, there will remain 434,049,542 cubic feet, say 434 millions cubic feet, which would keep the canal flowing 2 feet deep for 60 days† and would be sufficient to irrigate 4,340 acres, assuming 100,000 cubic feet sufficient per acre, from which the following return may be calculated :—

**Calculations of Returns from the Reservoir.**

| | | Rs. |
|---|---|---|
| 54. 4,340 acres water-rate @ Re. 1-8 per acre ... ... | = | 6,510 |
| Enhancement of revenue @ Rs.5 per acre ... | = | 21,700 |
| Total Rs. | ... | 28,210 |

* Cost of weir. Cost of canal.
21858 + 124178 = 146036
146036 : 100 :: 11000 : x
∴ x = 7·53.

† Suppose canal to run 2 feet deep, Reservoir = 578732728 cubic feet.
To find how long it would supply the canal, deducting $\frac{1}{4}$ for loss $\frac{578732722}{4} = 144683180$ cubic feet,
the balance then would be (578732722 = 144683180) = 434049542 cubic feet.
Let x = No. of days canal to run 2 feet deep or 80 cubic feet per second discharge.

$$x \times 24\text{ h.} \times 60\text{ m.} \times 60\text{ s.} \times 80\text{ c. ft.} = 434049542$$

$$\therefore x = \frac{434049542}{24 \times 60 \times 60 \times 80} = 62·6.$$

| | | Rs. |
|---|---|---|
| *Deduct*— | | |
| For maintenance, Re. 1 per acre | = | 4,340 |
| Balance | = | 23,870 |
| Adding returns anticipated from Canal as above ... | = | 11,000 |
| Total Rs. | ... | 34,870 |

**Probable Percentage on the total outlay.**

which would give a return of 15·38* per cent. on the total outlay.

---

* Cost of weir. 21,858 + Cost of canal. 1,24,178 + Cost of Reservoir. 80,624 = 2,26,660.

2,26,660 : 100 :: 34,870 : x.

$$\therefore x = \frac{34{,}870 \times 100}{2{,}26{,}660} = 15{\cdot}38.$$

The Surveys, Plans and Estimates of this Project have been prepared by Overseer Sookh Lall.

S. S. JACOB, MAJOR,
*Executive Engineer, Jeypore State.*

JEYPORE, *November* 1879.

# PUBLIC WORKS DEPARTMENT,

## JEYPORE STATE.

# REPORT

ON THE

# BOOCHARA IRRIGATION PROJECT.

Printed by Thos D Bona, Thomason College Press, Roorkee,—1884

# BOOCHARA IRRIGATION PROJECT.

## INDEX.



### APPENDIX.



### DIAGRAMS.

# PUBLIC WORKS DEPARTMENT,

## JEYPORE STATE.

# REPORT

ON THE

# BOOCHARA IRRIGATION PROJECT.

**General description of Site.**

1. Boochara, a large village of Torawatee, is situated among the hills about 50 miles north of Jeypore, and 30 miles south-east of Khetree.

About 1½ miles west of Boochara the two nullahs (namely, Pandaree and Cheeplata) rising in the hills near Toda, Cheeplata, &c., run down a distance of about 12 miles, meeting each other near Pahareewalla, and form one large nullah, called the Sota; this falls into the river Savee beyond Kote Pootlee, about 20 miles from Boochara.

**General description of Project.**

2. The project consists in throwing a masonry dam across a narrow gorge near the village of Pahareewalla; and two earthen bunds, one towards the east and the other north; the water thus stored will be sufficient to irrigate the land lying between the Sota and the Savee rivers, known as the district of Kote Pootlee, in area about 70 square miles.

3. The site selected for this dam is a little below the village of Pahareewalla; the valley is steep and rocky, and adapted for storage. The dam across the valley is placed about 1,000 feet below the junction of the main stream with one of its principal tributaries, the Cheeplata nullah; the site is favorable from the contraction of the valley at this point, and from there being solid rock all throughout the bed and sides of the nullah, for foundations and for the ends of the dam.

4. The Index Map attached shows the drainage area, the site for the lake, and the land it is proposed to irrigate.

**General description of the Masonry and Earthen Dams proposed.**

5. The masonry dam will be 472 feet in length at top, and 85 feet high in the centre of the valley, its thickness at bottom 65 feet, and at top 13 feet, batter in face 1 in 15. The top of the dam to be

10 feet above the highest flood line, and in addition there will be a parapet wall 2 feet high.

This will form a reservoir 1¾ square miles in area, extending about 3¼ miles up the valley, the greatest depth of water being 75 feet, and the mean depth 27·32 feet.

One earthen bund will be 2,200 feet in length and 25 feet high in the centre, and the other 800 feet long and 11½ feet high, the earthwork on the outside face to have a slope of 2 to 1, and on the inside 4 to 1, the inner face to be pitched or covered with ballast 12 inches deep, and the outside to be turfed.

These bunds will be made 15 feet higher than the high water line.

A pucka rubble masonry core wall will be built into the body of the bunds if necessary, in height to 3 feet above the highest flood-level.

**Drainage Area.**

6. The area drained by this nullah above the proposed site for the dam is 80 square miles, and the whole of the country comprised within the watershed line is steep and of a rocky formation.

**Discharge of Nullah, theoretical.**

7. The theoretical discharge of the flood is 25,813 cubic feet per second, (Appendix A,) and the waste weir has been calculated accordingly (Appendix B).

In the Sota Branch the slope of the bed is 16·65 feet per mile. In the Cheeplata Branch 16·71 feet per mile.

**Discharge of Nullah, calculated from the average rainfall, showing probable quantity of water which will be available for storage.**

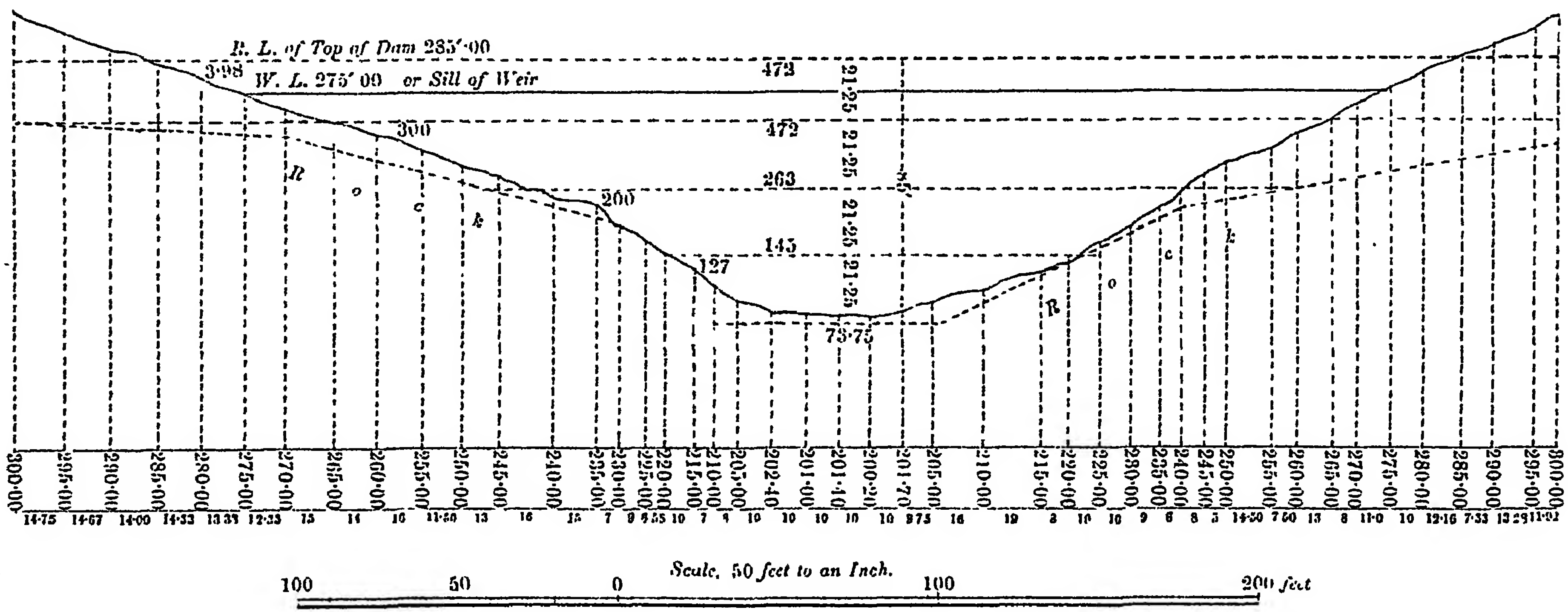
8. As this year (1878) has been one of drought, we have taken the average rainfall of previous years in the neighbourhood of the country drained by the Banganga, (as ascertained by the register of rain gauge kept at Myre to find the ratio of drainage of the Banganga river over its basin,) and assume it to be 30 inches.

Let us assume one-third of the rainfall, or 10 inches, as the actual run off as proved by the rainfall on 18th December 1877 from actual gaugings taken (Appendix D).

9. Then the quantity of water available from the area of 80 square miles will be 1,858,560,000

# Boochara Irrigation Project.

## CROSS SECTION OF NULLA AT SITE OF DAM.



cubic feet, in round numbers 1,858 millions cubic feet.*

**Contents of the proposed Lake.**

10. The contents of the reservoir have been calculated from 28 cross-sections, the details of which are in the manuscript copy of the Report in the Executive Engineer's office. At 20, 60, 70, and 75 feet contours, the contents are as follows in round numbers :—

| | | | | |
|---|---|---|---|---|
| At 20 feet contour, | 11 | millions | cubic | feet. |
| „ 60 „ „ | 696 | „ | „ | |
| „ 70 „ „ | 1,118 | „ | „ | |
| „ 75 „ „ | 1,328 | „ | „ | |

**Proposed allowance of water for Irrigation Canal.**

11. As there are about 70 square miles of good land below the dam available for irrigation, it is proposed to calculate for a discharge of 65 cubic feet a second ; this would be sufficient for one crop over the whole season, generally extending over 4 months. If all is not used, there will remain a balance for the next year's supply.

**Quantity required for Irrigation, loss by Evaporation and other causes.**

12. The quantity of water required to keep a constant discharge of 65 cubic feet a second is 673,920,000 cubic feet; nearly 674 millions cubic feet.†

Besides this, if we allow 20 feet of water to remain in the tank as not being available for irrigation, owing to the great expense of making an outlet for it, and also allow the upper 5 feet of the whole contents to be lost by evaporation, which is a liberal allowance, we shall then have the actual quantity of water which will be required each year as follows :—

| | |
|---|---|
| To keep canal flowing for 4 months with 65 cubic feet per second, | 673,920,000 |
| ‡ Loss in the bed of reservoir below 20 feet contour, ... ... | 11,330,000 |
| § Loss by evaporation contents of upper 5 feet, ... ... ... | 210,622,945 |
| Total cubic feet, ... | 895,172,245 |

* sq. m. 80 × ft. 5280 × ft. 5280 × in. 144 = 3,211,591,680 square inches; if 10 inches of rainfall is taken as the run off, then we have—3,211,591,680 × 10 ÷ 1728 = 1,858,560,000 cubic feet as the probable amount of water which will be available for storage.

† m. 4 × d. 30 × h. 24 × m. 60 × sec. 60 × c. ft. 65 = 673,920,000.

‡ Area 20 feet contour l. 4000 × b. 250 = 1,000,000 square feet.
Mean depth of 20 feet = 11·33
Cubic contents = 1,000,000 × 11·33 = 11,330,000.

§ Area at 75 feet contour = 12,121,589.
Cubic contents of upper 5 feet = 12,121,589 × 5 = 210,622,945.

That is, in round numbers, the total quantity of water which will be required to meet all demands will be about 895 millions cubic feet.

**Quantity required yearly to replenish Reservoir.**

13. The contents of the reservoir as stated above are 1,329 millions, and the quantity required to meet all demands 895 millions cubic feet. This leaves (1,329 — 895) 434 millions as a balance in the reservoir available as a reserve for the next season.

**A rainfall of 7 inches sufficient to furnish this.**

14. If this quantity remains in the tank, the water which would be required to meet all demands the following season would then be (895 — 434) 461 millions cubic feet. A rainfall of only 7½ inches over the drainage area, supposing one-third of it only ran off, would be sufficient to furnish this quantity.* It is very seldom there is such a small rainfall as this, and any rainfall in excess of 7½ inches would be so much to the good for the following year.

Although the water below the 20 feet contour would remain in the reservoir as unexpended, to be on the safe side it has been included in the quantity which would be annually required.

**Area of the Reservoirs at different contours.**

15. The area of the lake when full up to the level of waste weir, or 75 cubic feet, is 48,535,964 square feet, or 1·75 square miles, about $\frac{1}{46}$ of the catchment area.

That to the level of 60 feet is 37,267,092 square feet, or 1·336 square miles, or about $\frac{1}{60}$ of the area of catchment; and at 50 feet contour from bed the area is 30,360,092 square feet, or 1·089 square miles.

**Value of water stored.**

16. The estimate amounts to Rs. 3,21,345; so that the value of water stored at 75 feet contour is 4,135 cubic feet per rupee.

**Description of Waste Weirs.**

17. The waste weirs, three in number, making a total length of 1,300 feet, will be constructed as follows:—

*First,* 700 feet long to the west.
*Second,* 400 feet long to the north-east.
*Third,* 200 feet long also to the north-east of the dam.

---

* sq m. sq ft. in. rainfall
$80 \times 2,323,200 \times x =$ cubic feet required $= 461$ millions,

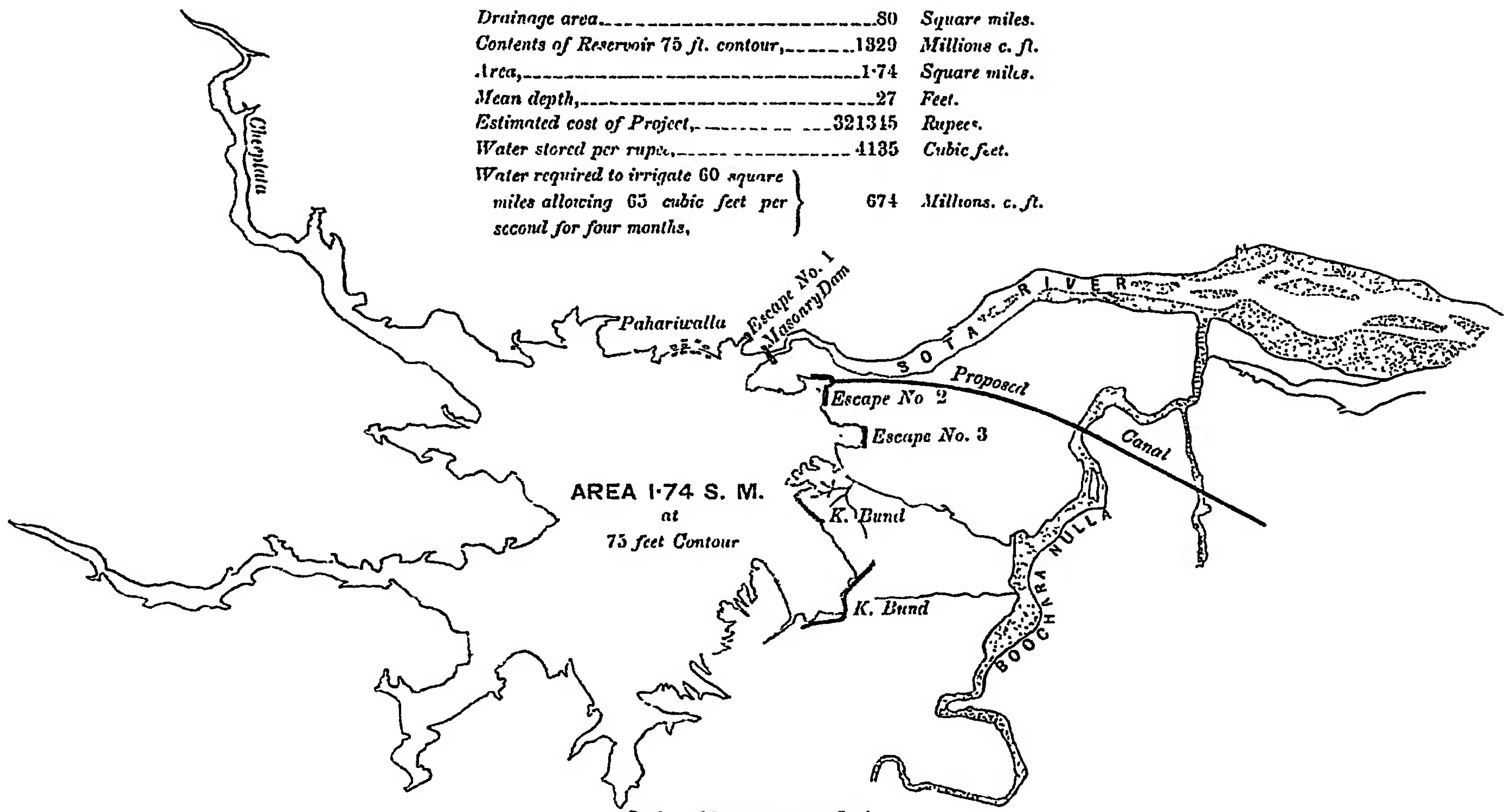
$$\therefore x = \frac{461,000,000}{80 \times 2,323,200} = 2 5 \text{ inches run off.}$$

If one-third of the actual fall is taken as the actual run off, then a rainfall of 7½ inches over the drainage area would be sufficient.

# BOOCHARA IRRIGATION PROJECT.

## PLAN OF RESERVOIR.

| | | |
|---|---|---|
| *Drainage area* | 80 | *Square miles.* |
| *Contents of Reservoir 75 ft. contour,* | 1329 | *Millions c. ft.* |
| *Area,* | 1·74 | *Square miles.* |
| *Mean depth,* | 27 | *Feet.* |
| *Estimated cost of Project,* | 321345 | *Rupees.* |
| *Water stored per rupee,* | 4135 | *Cubic feet.* |
| *Water required to irrigate 60 square miles allowing 65 cubic feet per second for four months,* | 674 | *Millions. c. ft.* |




*Scale, 3000 feet to an Inch.*

The first two of them will lead the waste water direct to the nullah about 400 feet below the dam, and the third will lead the water direct to a large nullah by which it will rejoin the original nullah, at a distance of a mile below the bund, no regular waste weir will be built, all that is necessary will be to cut and dress off the solid rock to be above widths, at the level of 75 feet above the bed of the nullah, at which level the sill of the weir will be on solid rock to resist the force of running water; all other details connected with them are shown in Plan.

The low places to be built up with rubble masonry as per Plans and Sections to the level of waste weir; and in addition to have a parapet wall 3 feet high.

**Discharge over Waste Weirs.**

18. The discharge over the crest of the waste weir will be 25,813 cubic feet per second with a length of 1,300 feet, and depth of 4 feet, which is the maximum depth provided for; first the reservoir will have to fill up, and then the water will have been escaping all the while, so that the flood line will never rise to the height of 4 feet except under a very heavy continuous rainfall of some days at a time, which is not known in these parts.

**Land submerged.**

19. Only the village Pahareewalla, consisting of 13 houses, and its Dhanee of 4 houses, will be submerged by the construction of this lake; a great part of the land which will be submerged is almost waste, with the exception of a few fields containing about 408 beegahs and 13 wells.

The land lost by submersion is shown in detail in the statement attached (Appendix F).

**Sluices.**

20. The regulating sluices for discharging water from this tank will consist of four circular gun-metal valves in duplicate, each 2 feet diameter, laid through the solid rock cut for the purpose as per design, separate from the pucka dam, and to the north-east of it (Appendix C), *see* also page 13.

**Main Canal.**

21. It is proposed to run the line of main canal for distributing the water on the right bank of the nullah, the length being about 20 miles to Kote Pootlee—branches would be taken off right and left to every village.

Although the level of the canal at the head is 20 feet above the bed of the nullah or bottom

of the lake, the quantity of water lost is only about 11,330,000 cubic feet, about $11\frac{1}{3}$ millions cubic feet, or about $\frac{1}{117}$ of the whole contents of the tank; this is not so valuable as the greater command of the country which will be obtained by a higher level, and is not worth the great expense which would be incurred in cutting the sluices down to this level. The canal will have to be carried across two nullahs.

*It is proposed to do this by means of* iron troughs 3 feet in diameter, supported on iron trestles or masonry piers built in the bed of the nullahs; at present only four troughs are taken in the estimate.

The canal is capable of discharging 116 cubic feet per second to allow for demands which may occur.

Its bottom breadth is 10 feet; depth of water 3 feet, side slope 1 to 1 (Appendix G).

**Estimated amount of Project.**

22. The estimate for the whole work, including 20 miles of main canal and 50 miles of distributaries, amounts to Rs. 3,21,345.

The details of this are in the manuscript copy of the Report in the Executive Engineer's office, but the Abstract is given on page 15 at the end of this Report.

The masonry sluices to regulate the supply to *the distributaries will consist of planks in a verti*cal cutstone groove; one will be required at the head of each distributary, and though the cost has not been included in the estimate, the rates taken will I believe cover the cost.

**Probable Return upon Expenditure.**

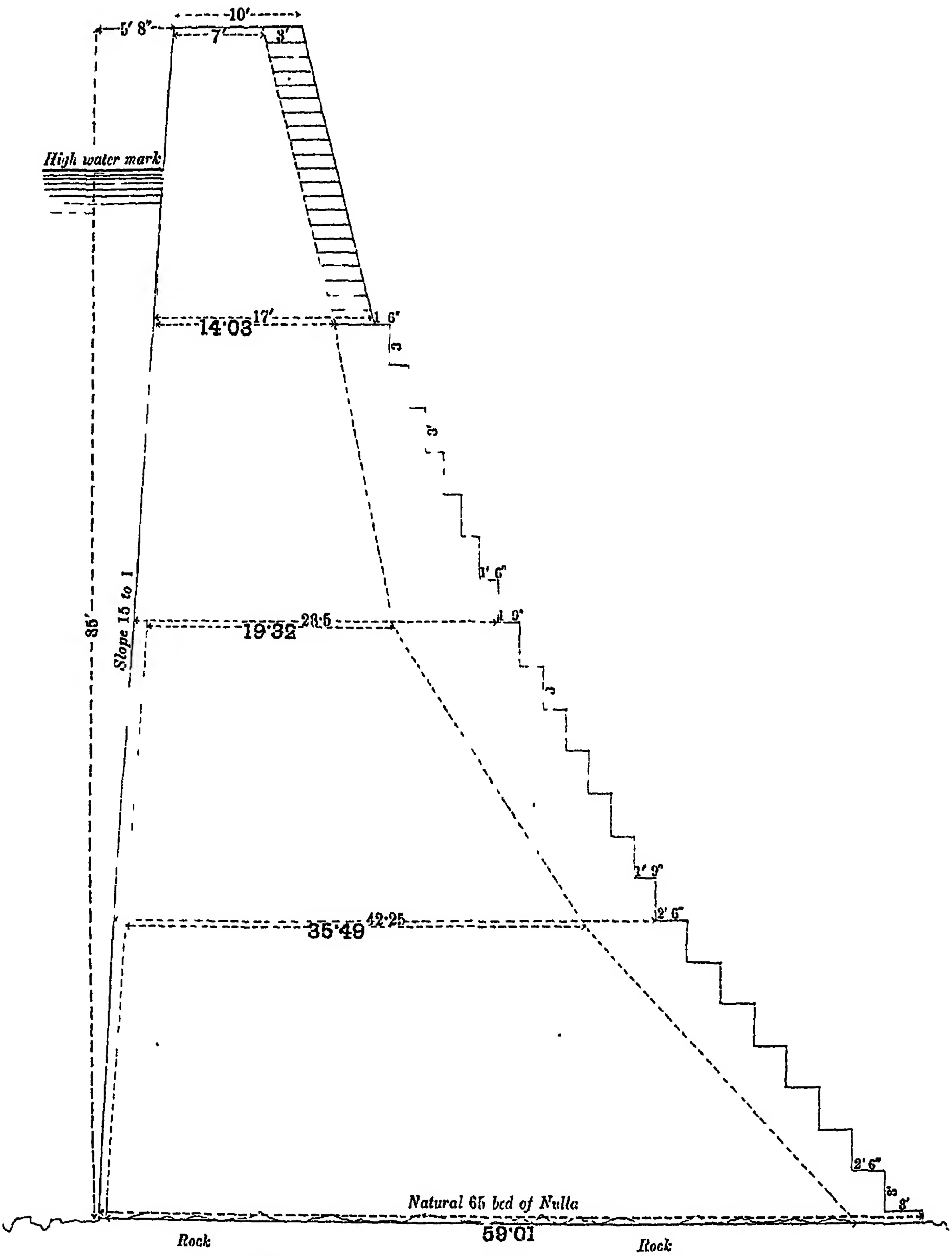
23. To calculate what will be the probable return on this expenditure, the area of land below the dam which can be irrigated is 70 square miles; say 30 square miles only are suitable for irrigation.

Allow 200 acres in each square mile as what will be actually irrigated; that is about one-third only, two-thirds being considered unirrigable on account of nullahs, villages, &c.

Then 30 miles $\times$ 200 acres $=$ 6000 acres $=$ 18,000 beegahs.

# Boochara Irrigation Project.

## PROPOSED SECTION OF MASONRY DAM.




*Theoretical Section by Molesworth's formula shown in dotted lines, thus*
*Section adopted shown in black lines.*

*Scale, 10 feet to an Inch.*

| | Rs. |
|---|---|
| Water rate of 18,000 beegahs at 8 annas per beegah, ... ... | 9,000 |
| Share of produce, say Rs. 2 per beegah, ... ... ... | 36,000 |
| Total Rs., ... | 45,000 |
| *Deduct*— | |
| 4 annas a beegah for annual maintenance, ... ... ... | 4,500 |
| This leaves total balance return of Rs., | 40,500 |

which gives about 12½ per cent. on the outlay; this may not be obtained for a few years, but ought eventually to be exceeded.

**Calculations for thickness of Masonry Dam.**

24. On Appendix H. will be found the calculations for the thickness of the dam.

**Reference to the share Khetree has in the Project.**

25. As the site for the reservoir and the drainage area are all in the Jeypore lands, while the district which will be irrigated, viz., Kote Pootlee belongs to the Khetree Raja, it would be necessary to make some arrangement beforehand to avoid any misunderstanding in collecting the revenue from irrigation. It is to the advantage of both that the water should be stored and fully utilized instead of going every year to waste as it now does. It is seldom such an opportunity is offered of storing such a volume of water, sufficient to insure the Kote Pootlee district in fact from famine; and if from any petty misunderstanding the work is not carried out as soon as funds are available, it will I think be a matter of deep regret.

**System proposed for sharing Expenditure and realizing the Revenue.**

If these returns were made dependent upon the area irrigated, it would be very uncertain, and would necessitate measurement of the land every year by some Agent from the Jeypore Durbar, and would perhaps give rise to discussion or dissatisfaction to one side or the other.

The plan which appears to me to be the most simple and feasible is for Khetree to pay Jeypore 3 per cent. the first 3 years, and 5 per cent. afterwards, on all expenditure incurred by Jeypore; and for Khetree to have the use of all the water, and make as much out of it as it could.

The reason 3 per cent. is proposed for the first 3 years, is because no irrigation work will yield its full returns much under 3 years; but after this period Khetree would pay 5 per cent. on all that Jeypore had spent, and ought to realize far more from the irrigation.

It might be allowed to be optional for Khetree to make all the irrigation channels in the Khetree lands at its own expense; in this case it would pay less interest annually, or Jeypore might carry out the whole work including the system of distributary channels, and Khetree would pay interest on the whole expenditure.

**Amount payable by Khetree.**

In the latter case the charges would be as follows:—

| | Rs. |
|---|---|
| Total cost of project, ... ... | 3,21,345 |
| Interest on the above at 3 per cent., ... ... ... ... | 9,640 |
| Interest on the above at 5 per cent., ... ... ... ... | 16,067 |

Khetree would thus have to pay for the first 3 years annually Rs. 9,640: and afterwards Rs. 16,067 annually.

In the second case if Khetree made the canal and distributaries at its own cost, the payment would be as follows, the—

| | Rs. |
|---|---|
| Jeypore expenditure, ... ... | 2,65,956 |
| Khetree " ... ... | 55,389 |
| Interest for 3 years on Rs. 2,65,956, at 3 per cent. per annum, ... | 7,978 |
| Afterwards on Rs. 2,65,956 at 5 per cent., ... ... ... | 13,297 |

The returns on the project if the water is properly used, ought not to be less than Rs. 40,500 per annum, as explained on page 9; so that Khetree after paying Jeypore the interest as above, ought to realize a good profit; and in a year of drought, the immunity from actual loss, afforded by the reservoir, would be of untold value.

Each party should arrange for any repairs which might be necessary at any time within its own border, and these charges should not be allowed to interfere with, or alter in any way, the interest charges due to Jeypore, which should be ratified in the first instance by the paramount power and remain fixed, no matter what the profits might be to Khetree.

Under this system, if approved by both Jeypore and Khetree, I do not think there could arise any misunderstanding.

**Report by Superintending Engineer upon this Project.**

26. Mr. Crommelin, when Superintending Engineer of Rajputana, visited the site with me in January 1879, and I cannot do better than quote his remarks on the project; he reports—

"The site of the dam is peculiarly favorable. It is difficult to conceive that the drainage of 80 square miles can pass through so narrow a gorge. Its rocky nature is peculiarly suited for a dam, and renders all deep foundations unnecessary. I do not remember ever having seen a more suitable site. In consequence the cost of the dam will be but trifling in comparison with that of others impounding a much smaller quantity of water.

"The escapes, which are of sufficient total length, will be somewhat costly, as considerable blasting will have to be done; but their cost is amply provided for in the estimate.

"The first mile of the main irrigating duct will be also somewhat expensive, as there will be some rock cutting and a nullah to be crossed; but this has also all been amply provided for in the estimate.

"The catchment area, through most of which I rode, is particularly favorable for a free run off; it being generally of a stony nature and not partaking of the sandy character so prevalent in Rajputana.

"In fact I consider the calculations of the quantity of water likely to be stored to be very reasonable, and the return to be expected to be fair in every way.

"But it must be borne in mind that these returns depend entirely on the area of cultivable ground below the tank, and on the sufficiency and willingness of cultivators to take advantage of the water placed at their disposal. On this subject I can give, of course, no opinion. I can only say to the best of my belief, the quantity of water estimated will be collected at a cost of not more than about 3 lakhs of rupees; that the works themselves are well designed and not excessive in strength or cost, and that if cultivators are to be found who will fully utilize all the water available, the project should be a very paying one for the State, and an incalculable blessing to all having land below the tank."

**Project by whom prepared.**

27. The project has been prepared by Pundit Ghasi Ram, Assistant Engineer, and Sub-Overseer Kunbya Lal.

In conclusion, I commend the project to the careful consideration of the Maharajah and his Council.

S. S. JACOB, Major,
*Executive Engineer,*
*Jeypore State.*

## SPECIFICATION.

**Rubble Masonry Dam.**

28. The dimensions of the dam and all details are shown in the Plan and Section.

The foundation will be carried down to the solid rock, the surface of the rock is to be cut into horizontal and vertical steps throughout the entire length of the dam.

The bed to present a rough surface, so that the dam masonry and the solid rock shall break joint at their junction, and not have any continuous joints through.

No filling in of the foundation is to be commenced till the excavation has been cleared of water, and the solid rock properly prepared to receive it, and approved of by the Executive Engineer; if any flaws exist in the rock, they should be well cleaned out and filled with cement.

The foundation must be kept clear of water during the execution of the masonry.

The masonry of the dam will consist of uncoursed rubble without any levelling courses, the dam will be simply a mass of uncoursed rubble without any hollows; every portion resembling the rest of the work as closely as possible.

**Materials.**

The materials shall be approved of by the Executive Engineer before any work is commenced. There is plenty of good building stone not far off from the site, but the kunkur will have to be brought from a distance.

All stones are to be laid on their natural beds; on the batter side, the beds of the stones are to be at right angles to the batter.

No stone to have a bed less than one-third more than the average thickness of the course in which it occurs.

About one-fifth of the whole length of each course to be headers, no header to be less than 2½ feet in length.

The beds are to be dressed so as to rest evenly on the mortar without any hollows and projections.

The faces of the stones to be left rough, but no part to project more than one inch beyond the face alignment.

The joints to be dressed square, true, and full, and no mortar joint to exceed half an inch in thickness.

No stone should weigh more than 5 maunds nor less than one maund, the packing stones should not weigh less than 5 seers, no small chips to be used on any account, and no hollows to be left between the stones.

Stones are to be washed, cleaned of all impurities and wetted before being used.

The masonry to be kept wet during construction, and till at least two months after completion.

The face and rear of the dam to be raked out and pointed with kunkur lime.

**Cement.**

The cement to be used will be of kunkur obtained from the village Cheeplata or Pursotpura, burnt in an ordinary native kiln, all the ashes to be carefully removed from the burnt lime before it is thrown into the mortar grinding mills.

Its breaking weight not to be less than 120 lbs. per square inch.

**Concrete.**

Concrete composed of 4 parts of stone, broken to 1½ inch size, 2 parts of small clean kunkur, and one part of kunkur lime, by measure, to be used only in the foundations of the pucka dam, core, and dam walls. It is to be laid from 1 to 2 feet thick, and consolidated in layers of 6 inches thick, each layer to be well watered and rammed before the next is put on.

Such proportion of bujree to be mixed with the lime as may be proved by experiment to be advisable.

**Outlet Pipes and Valves.**

The outlet from the reservoir will be through solid cutstone pipes each 2 feet in diameter—these will be closed on the inner or water face by gunmetal face valves, which will be raised by vertical rods with screwed heads. Duplicate valves will be provided to each outlet, in case of necessity these can be closed, but as a rule they will always be open.

**Stone Murwas.**

Stone murwas are to be built into the face of the dam at a distance of 10 feet from each other horizontally, and at every 6 feet in height.

## EARTHEN BUNDS.

To be constructed as per Sections and Plans.

**Marking out.**

The centre line and the side slopes to be marked out with a deep daghbell, and stones to be placed at every 100 feet to mark permanently the inner and outer edges of the side slopes.

**Precautions.**

The surface of the ground at site to be excavated 6 inches deep, all the jungle and grass roots to be cut and removed so as to ensure proper footing, the top soil thus obtained containing jungle and grass roots, &c., &c., is not to be used in the body of the bunds, but when the bund is finished it is to be used in covering the side slopes.

**Earthwork.**

No earth is to be excavated within 50 feet of the edge of the side slope at its greatest height, and the depth of excavation not to be more than 3 feet, to be increased as the distance recedes from the foot of the bund, to obtain the quantity of earth required. The earthen bunds to be always kept higher than the masonry dam during progress.

The earth is to be deposited in layers of 12 inches each, kept lower in the centre and well rammed with plenty of water.

Another layer should not be commenced till the first is properly done as described above.

The inner slope to be covered with dry stone pitching 12 inches thick on a layer of broken stone 6 inches deep, and the outer slope to be turfed.

A core wall to be built into the body of the bunds, in height to 3 feet above the highest flood line, as per Plans and Sections.

29. *ABSTRACT ESTIMATE.*

| Quantity. | Items. | Rate. | | | Per. | Amount. | | | Total. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | JEYPORE. | | | | | | | | | | |
| 248,175 C. ft. | Excavation for foundation, ... ... | 20 | 0 | 0 | °/oo | 4,964 | 0 | 0 | | | |
| 39,418 „ | Concrete „ „ ... ... | 14 | 0 | 0 | °/o | 5,518 | 0 | 0 | | | |
| 894,424 „ | Pucka rubble masonry, ... ... | 18 | 0 | 0 | °/o | 1,60,996 | 0 | 0 | | | |
| 1,773,013 „ | Rock cutting, ... ... ... | 20 | 0 | 0 | °/oo | 35,460 | 0 | 0 | | | |
| 573,202 „ | Excavation outlet, Channel, hard soil, | 10 | 0 | 0 | °/oo | 5,732 | 0 | 0 | | | |
| 1,174,800 „ | Earthwork, ... ... ... ... | 6 | 0 | 0 | °/oo | 7,049 | 0 | 0 | | | |
| 81,548 „ | Ballast, ... ... ... ... | 10 | 0 | 0 | °/oo | 815 | 0 | 0 | | | |
| 84,736 S. ft. | Turfing, ... ... ... ... | 2 | 0 | 0 | °/o | 1,695 | 0 | 0 | | | |
| 27,000 C. ft. | Dry packing stones, ... ... ... | 5 | 0 | 0 | °/o | 1,350 | 0 | 0 | | | |
| 8 No. | Gun-metal iron screw valves, ... | 750 | 0 | 0 | pair. | 3,000 | 0 | 0 | | | |
| 1,808 C. ft. | Outlet cut-stone pipes, 2 ft. diameter, | 3 | 0 | 0 | c. ft. | 5,424 | 0 | 0 | | | |
| 344 No. | Stone Murwas, ... ... ... | 2 | 0 | 0 | each | 688 | 0 | 0 | | | |
| 85 R. ft. | Stone water gauge, ... ... ... | 5 | 8 | 0 | r. ft. | 467 | 0 | 0 | | | |
| | Bailing out water, ... ... ... | ... | ... | ... | ... | 1,000 | 0 | 0 | | | |
| | Overseer's quarters, ... ... ... | ... | ... | ... | ... | 1,000 | 0 | 0 | | | |
| | Sheds for work-people, ... ... | ... | ... | ... | ... | 1,000 | 0 | 0 | | | |
| | Surveying expenses, ... ... ... | ... | ... | ... | ... | 2,000 | 0 | 0 | | | |
| | Compensation for Pahareewalla and its Dhanee, ... ... ... ... | ... | ... | ... | ... | 1,020 | 0 | 0 | | | |
| 13 No. | Compensation for 13 wells, ... ... | 200 | 0 | 0 | each | 2,600 | 0 | 0 | | | |
| | Total Rupees, ... | ... | ... | ... | ... | 2,41,778 | 0 | 0 | | | |
| | Contingencies, ... ... ... | 10 | 0 | 0 | °/o | 24,178 | 0 | 0 | 2,65,956 | 0 | 0 |
| | KHETREE. | | | | | | | | | | |
| 5,913,600 C. ft. | Excavating canal, ... ... ... | 4 | 0 | 0 | °/oo | 23,654 | 0 | 0 | | | |
| 50 Miles. | Distributaries, ... ... ... | 300 | 0 | 0 | mile. | 15,000 | 0 | 0 | | | |
| 1,300 R. ft. | Iron troughs, 2 ft. diameter, ... | 4 | 0 | 0 | r. ft. | 5,200 | 0 | 0 | | | |
| 130 No. | Iron posts, pair, ... ... ... | 50 | 0 | 0 | each | 6,500 | 0 | 0 | | | |
| | Total Rupees, ... | ... | ... | ... | ... | 50,354 | 0 | 0 | | | |
| | Contingencies, ... ... ... | 10 | 0 | 0 | °/o | 5,035 | 0 | 0 | 55,389 | 0 | 0 |
| | Grand Total Rupees, ... ... | | | | | | | | 3,21,345 | 0 | 0 |

## Appendix A.

*Flood Discharge.*

1. By Col. Dicken's Formula—

$D = 825\, m^{\frac{3}{4}}$; Where $m$ = 80·00 square miles of drainage area.

$= \log 825 + \frac{3}{4}\log m$

$= \log 825 + 3 \log m \div 4$

$\log 825 = 2{\cdot}9164539 = 2{\cdot}9164539 + \log 80{\cdot}00$

$= 1{\cdot}9030900$

$3$

$4)\overline{5{\cdot}7092700}$

$\overline{1{\cdot}4273175} = + 1{\cdot}4273175$

Total $= 4{\cdot}3437714$ = No. 22,068 cubic feet per second.

2. By Burgess's Formula—

$D = 1800 \dfrac{A}{\sqrt[3]{L^2}}$

$D = 1300 \dfrac{A}{\sqrt[3]{L^2}}$

$= \log 1300 + \log A - \frac{2}{3}\log L$

$= \log 1300 + \log 80{\cdot}00 - (2 \log 12 \div 3)$

$\log 1300 = 3{\cdot}1139134$

$\log 80{\cdot}00 = 1{\cdot}9030900$

$\overline{5{\cdot}0170334}$ –

$\log 12 = 1{\cdot}0791812$

$2$

$3)\overline{2{\cdot}1583624}$

$\overline{0{\cdot}7194541} = - \dfrac{0{\cdot}7194541}{4{\cdot}2975793}$ Diff.

= No. 19,841 cubic feet.

Here A = Drainage area in square miles.
L = Length of main river in miles.
= 12 miles, 1300 = co-efficient which in this case is accurate for places 1,300 feet above sea, and with a maximum rainfall in 12 hours of 5 to 6 inches.

The Bandi is 1,360 feet above the sea, but a maximum rainfall of 8 inches in 12 hours was gauged in August 1873 at Myro on the basin of the Banganga.

3. By Col. O'Connel's Formula—

$Y = m\sqrt{x}$

$= 130 \times (80{\cdot}00)^{\frac{1}{2}}$

$= \log 130 + \frac{1}{2}\log 80{\cdot}00$

$\log 130 = 2{\cdot}1139134 +$

$\log 80{\cdot}00 = 2)\overline{1{\cdot}9030900}$

$\overline{0{\cdot}9515450} = + \dfrac{0{\cdot}9515450}{3{\cdot}0654584}$ Total.

$= 1162{\cdot}7$ cubic yards $\times 27 = 31392{\cdot}9$ cubic feet per second.

Where $x$ = Drainage area in square miles.
$y$ = Flood discharge in cubic yards per second.
$m$ = 130 co-efficient.

Hence we have—

| | | |
|---|---|---|
| By Col. Dicken's Formula, | ... ... ... ... | 22,068 cubic feet. |
| By Mr. Burgess's „ | ... ... ... ... | 19,841 „ |
| By Col. O'Connel's „ | ... ... ... ... | 31,392 „ |

Therefore average discharge = 24,433 cubic feet per second.

*Secondly.* Here the lake drains an area of 80 square miles—it may be assumed that the greatest flood falling into the lake is equivalent to half inch of rain falling over the catchment in an hour.

Therefore the flood discharge per second $= \dfrac{2323200 \times 0{\cdot}5 \times 80}{60 \times 60}$ = 25,813 cubic feet per second, or = 1,548,780 cubic feet per minute.

25,813 cubic feet per second may be assumed as the flood discharge of the river during the highest flood, and this quantity has been taken for calculating the dimensions of the waste weir.

## Appendix B.

*Calculation for Waste Weir. Discharge over Weir.*

*1st.* By Col. Crofton's Formula, $D = 201{\cdot}6 \times L \times \sqrt{H^3}$.

*2nd.* By Beardmore's Formula, $D = 214 \times L \times \sqrt{H^3} \times {\cdot}75$.

Where $D$ = Flood dicharge of the river—25,813 cubic feet per second, or 1,548,780 cubic feet per minute.

$L$ = Length of the weir.

$H$ = Height of water over crest of weir = 4 feet.

(1). $1{,}548{,}780 = 201{\cdot}6 \times L \times \sqrt{4^3}$
$= 201{\cdot}6 \times L \times \sqrt{64}$
$= 201{\cdot}6 \times L \times 8$
$= L \times 1612{\cdot}8$

or $L = \frac{1548780}{1612{\cdot}8} = 960$ feet.

(2). $1{,}548{,}780 = 214 \times L \times \sqrt{4^3} \times {\cdot}75$
$= 214 \times L \times \sqrt{64} \times {\cdot}75$
$= 214 \times L \times 8 \times {\cdot}75 = 214 \times L \times 6$
$= L \times 1284$

or $L = \frac{1548780}{1284} = 1206{\cdot}2$ feet.

Therefore the length of the waste weir with 4 feet of water flowing over its crest is—

(1). By Col. Crofton's Formula, ... ... ... ... ... 960 feet,

(2). By Mr. Beardmore's Formula, ... ... ... ... 1,206 „

to be on the safe side 1,300 feet have been provided.

## Appendix C.

*Number of Sluices required. Calculation for Sluices.*

Calculation showing the number of sluices required to give the full discharge of 65 cubic feet a second, when the water in the tank is low.

When the water is low in the tank, a head of 1 foot of water is all that can be calculated on.

The diameter of the sluice proposed is 2 feet, and applying the formula $D = 3{\cdot}9 \times d^2 \times \sqrt{h}$;

Where $D$ = Discharge through pipe.

$d$ = Diameter of the pipe.

$h$ = 1 foot the head of water.

Then we shall have $D = 3{\cdot}9 \times d^2 \times \sqrt{h} = 3{\cdot}9 \times 2^2 \times \sqrt{1}$
$= 3{\cdot}9 \times 4 \times 1 = 15{\cdot}6$ cubic feet per second.

*From Molesworth.*

*2ndly.* $E = V.K.$
$Q = E.A.$

Here $A$ = 3 feet square.
$V$ = 8 feet.
$K$ = 0·68.

Therefore $Q = V, K, A$
$= 8 \times 0{\cdot}68 \times 3 \times 1$
$= 16{\cdot}32$ cubic feet per second,

or 4 sluices with 1 foot head will be necessary to give a discharge of 65 cubic feet a second.

## Appendix D.

*Ratio of drainage to downfall over the basin of Sota River.*

Ratio of drainage to downfall over the basin ascertained on 18th December, 1877.

Fall of rain at Boochara, 1 inch by rain gauge at 7 a.m. of the 18th December, 1877.

Flood commenced at 8 a.m. in the morning, and continued to 2 a.m. of the night; lasted 18 hours.

Say full discharge = 9 hours.

Top breadth of section = 65 feet.
Perimeter = 63·3 feet.
Mean depth of water = $\frac{26\cdot12}{8}$ = 3·26
Area of section = 64 × 3·26 = 208·64 square feet.

One inch of rainfall over 80 square miles = 185,856,000 cubic feet.

$$V = \sqrt{\frac{S}{B} \times 2f} \times \cdot92$$
$$= \sqrt{\frac{208\cdot64}{66\cdot3} \times 2 \times 16\cdot08} \times \cdot92$$
$$= \sqrt{3\cdot1469 \times 33\cdot36} \times \cdot92$$
$$= \sqrt{101\cdot98} \times \cdot92$$
$$= 10\cdot246 \times \cdot92 = 9\cdot426 \text{ feet per second.}$$

∴ Discharge = V × $s$ = 9·426 × 208·64 = 1966·64 cubic feet per second.

Now the flood discharge = 9 hours × 60 minutes × 60 seconds × 1966·64
= 63,719,136 cubic feet.

Since one inch of rainfall over 80 square miles is 185,856,000 cubic feet,

$$\therefore \frac{185,856,000}{63,719,136} = 2\cdot91, \text{ say } 3,$$

proving that the run off is about one-third of the fall.

## Appendix E.

*Detail of Waste Weir showing rock cutting and masonry required.*

*Waste Weir Escape No.* 1.

| No. of Section. | R. L. of Sill of Weir. | Mean height. | Distance. | Area. |
|---|---|---|---|---|
| 1 | 275 | 8·71 | 180 | 1567 |
| 2 | 275 | 11·14 | 230 | 2562 |
| 4 | 275 | 8·129 | 200 | 1625 |
| 5 | 275 | 1·51 | 76 | 105 |
| 6 | 275 | 8·346 | 180 | 1502 |

The total length of this escape is 700 feet, of which 140 feet will have to be built up.

∴ Actual length of rock cutting 700 — 140 = 560 feet.

Mean area of section = 1,472 square feet.

*Waste Weir Escape, No.* 2.

Cross-sections at this place show 4·02 feet as the mean height, and 415 feet as the length, of which 255 feet will have to be built up, and 160 feet to be cut out.

For details *see* Estimate and Plans in the Executive Engineer's office.

The masonry required to fill up the gaps will be as follows:—

| | | | | | | |
|---|---|---|---|---|---|---|
| Escape No. 1, | Mean length | 150, | Mean height | 3·63 |
| Escape No. 2, | „ | „ | 110, | „ | „ | 4·37 |
| „ „ | „ | „ | 200, | „ | „ | 11·73 |
| „ „ | „ | „ | 130, | „ | „ | 3·79 |
| „ „ | „ | „ | 60, | „ | „ | 2·18 |
| Escape No. 3, | „ | „ | 264, | „ | „ | 8·75 |

## Appendix F.

The following compensation will have to be allowed to the village of Pahareewalla and its Dhanee. For the nominal List, *see* the copy of estimate in the Executive Engineer's office.

| | Rs. |
|---|---|
| *Pahareewalla*— | |
| 13 Houses at Rs. 60, ... ... ... ... ... ... | 780 |
| *Dhanee*— | |
| 4 Houses at Rs. 60, ... ... ... ... ... ... | 240 |
| Total Rs., ... | 1,020 |

*Compensation.*

The land which will be submerged will be about 416 Jeypore beegahs of good soil bearing single and double crops, watered at present by 17 wells of sorts, as shown in the Statement below.

*Statement showing the number of wells and land bearing single and double crops, which will be submerged by the formation of the Boochara Lake.*

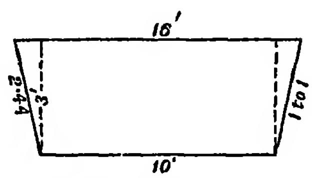
| No. | Name of Owners. | Name of Wells. | Land bearing crops. | | Total of each well. | | Grand Total. | |
|---|---|---|---|---|---|---|---|---|
| | | | Single. | Double. | Single. | Double. | Single. | Double. |
| | | | Kucha Beegahs | | | | | |
| 1 | Radha Kishen, ... ... | Badan Khor, ... ... | 20 | 20 | ... | ... | ... | ... |
| „ | Herda Ram, ... ... | Ditto, ... ... | 15 | 60 | 35 | 80 | ... | ... |
| 2 | Radha Kishen, ... ... | Dasoo Kho, ... ... | 20 | ... | 20 | ... | ... | ... |
| 3 | Ditto. ... ... | Peeplawalla, ... ... | 14 | 10 | 14 | 10 | ... | ... |
| 4 | Goolab Sing, ... ... | Aheeranwalla, ... ... | ... | 15 | ... | ... | ... | ... |
| „ | Dia Ram, ... ... ... | Ditto, ... ... | ... | 30 | ... | 45 | ... | ... |
| 5 | Goolab Sing, ... ... | Amursingwalla, ... ... | ... | 23 | ... | ... | ... | ... |
| „ | Dia Ram, ... ... ... | Ditto, ... ... | ... | 25 | ... | 48 | ... | ... |
| 6 | Goolab Sing, ... ... | Jataawalla, ... ... | 25 | 28 | 25 | 28 | ... | ... |
| 7 | Dia Ram, ... ... ... | Dia Ramjeewalla, ... | 25 | 30 | 25 | 30 | ... | ... |
| 8 | Kaisree Sing, ... ... | Loco Paree, ... ... | 60 | 27 | 60 | 27 | ... | ... |
| „ | Ditto, ... ... | Peerkhanwalla, ... ... | ... | 30 | ... | 30 | ... | ... |
| 9 | Herda Ram, ... ... | Goroonwalla, ... ... | ... | 35 | ... | 35 | ... | ... |
| 10 | Ditto, ... ... | Arawalla, ... ... | 30 | ... | 30 | ... | ... | ... |
| 11, 12 & 13 | Lumberdars of Boochara, ... | In Boochara nullah bed, ... | ... | 50 | ... | 50 | ... | ... |
| 14 | Jogianwalla, ... ... | Dharlee, ... ... ... | ... | 15 | ... | 15 | ... | ... |
| 15 | Sheeamee Bundrabunee, ... | Ditto, ... ... ... | ... | 10 | ... | 10 | ... | ... |
| 16 | Khatlee, ... ... ... | Ditto, ... ... ... | 40 | ... | 40 | ... | ... | ... |
| 17 | Baranee, ... ... ... | Ditto, ... ... ... | 175 | ... | 175 | ... | ... | ... |
| | | | 424 | 408 | 424 | 408 | 424 | 408 |

∴ Kucha beegahs $\frac{424 \times 408}{2}$ = 416 pucka Jeypore beegahs.

## Appendix G.

*Dimensions of the Main Canal.*

Area section $\frac{16 + 10}{2} \times 3 = 39$ square feet,




bed slope 2·5 feet per mile.

$$B = 18{\cdot}48 = 18{\cdot}5 \text{ feet,}$$

$$V = \sqrt{\frac{S}{B} \times 2f} \times {\cdot}92$$

$$= \sqrt{\frac{39}{18{\cdot}5} \times 5} \times {\cdot}92$$

$$= \sqrt{2{\cdot}1 \times 5} \times {\cdot}92 = \sqrt{10{\cdot}5} \times {\cdot}92 = 3{\cdot}24 \times {\cdot}92$$

$$= 2{\cdot}08 \text{ feet per second.}$$

$$D = S \times V = 39 \times 2{\cdot}98 = 116{\cdot}22 \text{ cubic feet per second.}$$

---

## Appendix H.

*Calculations for thickness of Masonry Dam.*

$H$ = Height of dam in feet = 85,

$x$ = Any depth below the surface of water in feet,

$y$ = Offset from vertical line to outer face of dam at any depth $x$ in feet,

$z$ = " " to inner face in feet.

$b$ = Width of dam in feet at top,

$a$ = Width of dam at $\frac{1}{4}$ feet from top in feet,

= 1·17, when $x = \frac{1}{4}$ feet,

$p$ = Limit of pressure allowed on the masonry in lbs. per square foot = 14,000 say.

Formula—

$$y = 7{\cdot}5\sqrt{\frac{x^3}{p}}\,;\; z = \frac{y}{10}\,;\; b = \frac{a}{2}$$

take $x = 21{\cdot}25$,

$$y = 7{\cdot}5\sqrt{\frac{(21{\cdot}25)^3}{14000}} = 6{\cdot}21,$$

$y$ however must not be less than $\cdot 6x$, and $\cdot 6x = 12{\cdot}75$,

and as $z = \frac{y}{10}$, $\therefore z = 1{\cdot}275$.

The thickness of the dam at one-quarter of the height therefore would be 12·75 + 1·275 = 14 feet. Similarly at a depth of 42·5 feet, the thickness of the dam would be

$$\overset{y}{17{\cdot}56} + \overset{z}{1{\cdot}756} = 19{\cdot}3,$$

and at depth of 63·75 feet the thickness of the dam would be

$$\overset{y}{32{\cdot}26} + \overset{z}{3{\cdot}226} = 35{\cdot}49,$$

and at a depth of 85 feet if we diminish the value of $p$ to 12,000 lbs., owing to the increased depth, we shall have thickness of dam at 85 feet =

$$\overset{y}{53{\cdot}65} + \overset{z}{5{\cdot}36} = 59 \text{ feet.}$$

The section which we have taken is thicker than is proved necessary by these calculations, but I prefer to have a good margin for safety.

The diagram above shows in dotted line the section of the masonry dam as found to be necessary by the above formula, and in black line the section decided upon for this project, the front and rear faces of the dam instead of being in curves as proposed by some Engineers, have been made in front at a fixed slope, and in rear with steps to economise scaffolding in building and for convenience afterwards.

# PUBLIC WORKS DEPARTMENT,

## JEYPORE STATE.

## REPORT

ON THE

# TORI IRRIGATION PROJECT.

A. ACTON: Calcutta Central Press Co, Ld., 5, Council House Street.

# INDEX.

## INTRODUCTION.



## PART I.–ENGINEERING.

### SECTION I.—GENERAL.



### SECTION II.—THE DAM.



### SECTION III.—CANAL.



### SECTION IV.—DISTRIBUTARIES.



## PART II.–FINANCIAL.

### COST.

## REVENUE.



## APPENDIX A.

# PUBLIC WORKS DEPARTMENT,

## JEYPORE STATE.

# REPORT

ON THE

# TORI IRRIGATION PROJECT.

## INTRODUCTION.

**Site defined.**

Tori is a small fortified jagheer village, situated about 7 miles to the south-east of Malpoora, 16 miles to the north of Toda, 24 miles to the west of Tonk, and 56 miles to the south-west of Jeypore.

**Course of the river Sohodra.**

The Sohodra river which passes about half a mile to the south of this village, has its source in the Ajmere territory, about 30 miles above the village of Tori, and receives several nullahs during its course. Its bed has a slope of 5 6 feet per mile. It drains an area of 350 square miles above the site proposed for the dam. See Index Map.

But as we have already constructed a reservoir on this drainage area at Bara Lamba which catches the rainfall of about 10 square miles, to be on the safe side in the calculations made for this project, the drainage area has been taken as 320 square miles.

When the river passes Tori, its bed becomes contracted, the land to the south being high, and the Tori hill confining it to the north; after flowing down a distance of 23 miles, it falls about 8 miles to the north of Tonk into the Mashi river, which again joins the Banas River at four miles north of Tonk.

**Object of the project.**

The project consists in throwing a dam across the river at Tori, and storing the flood waters for irrigation.

**Size compared with other lakes in Rajputana.**

The water thus stored would be sufficient for irrigation in the lower lands, during the rubbee season; and the reservoir formed would be next to the Dhabar or Jai Samand, the largest artificial lake in Rajputana.*

---

* Dhabar or Jai Samand is nearly 9 miles long by 5 miles wide, and covers an area of nearly 21 square miles, of which 0·8 square miles consist of islands. The area drained into it is 690 square miles. Its greatest depth is 78 feet.

Rao Samand is 3 miles long, width 1¼ miles, area 2·9 square miles, drainage area 194 square miles.

Uday Sagur is nearly 2¼ miles long by 1½ miles wide. Its area is 2 square miles, and area drained 179 square miles.

Picholla at Oodeypore is 2¼ miles long by 1¼ miles wide. Its area is 1·2 square miles, and it drains 56 square miles.

The water would extend six miles in length by about one in breadth, giving an area of 6·53 square miles. The average depth would be 9·6 feet, and the length of high water contour would be 24 miles.

For the sake of convenience this report is divided into two parts :—

I.—Engineering.

II.—Financial.

## PART I.—ENGINEERING.

**Section I.—General description of the drainage area.**

The area drained by this river above the site proposed for the dam is 350 square miles. The country comprised between the water shed line is of a mixed character; of a sandy and rocky formation; the lands to be irrigated are for the most part first class soil free from jungle.

**Downfall and ratio of drainage to downfall over the basin.**

The result of the register of rain gauges and observations conducted at different places in this state show 24 inches to be the average quantity of rainfall in these parts in ordinary years, and about one-third of it, or 8 inches, as the actual run off, and this ratio of drainage to downfall has been assumed in the calculations for this project.

**Discharge of the river.**

The theoretical discharge of the flood is 65,883 cubic feet per second, and the dimensions of the waste weir have been calculated accordingly.

**Longitudinal section at proposed site of Dam.**

The flood discharge from the cross section of the river and the highest water line shown by the villagers, calculated by the usual formula, comes to 50,201 cubic feet per second. For the longitudinal section along proposed site of Dam, see Diagram No. 2.

The entire length of the dam will be 6,600 feet.

**Height of top of dam above waste weir.**

The length of the masonry portion will be 3,200 feet, and will be 50 feet high, *i.e.*, 10 feet above high water mark, *viz.*:—

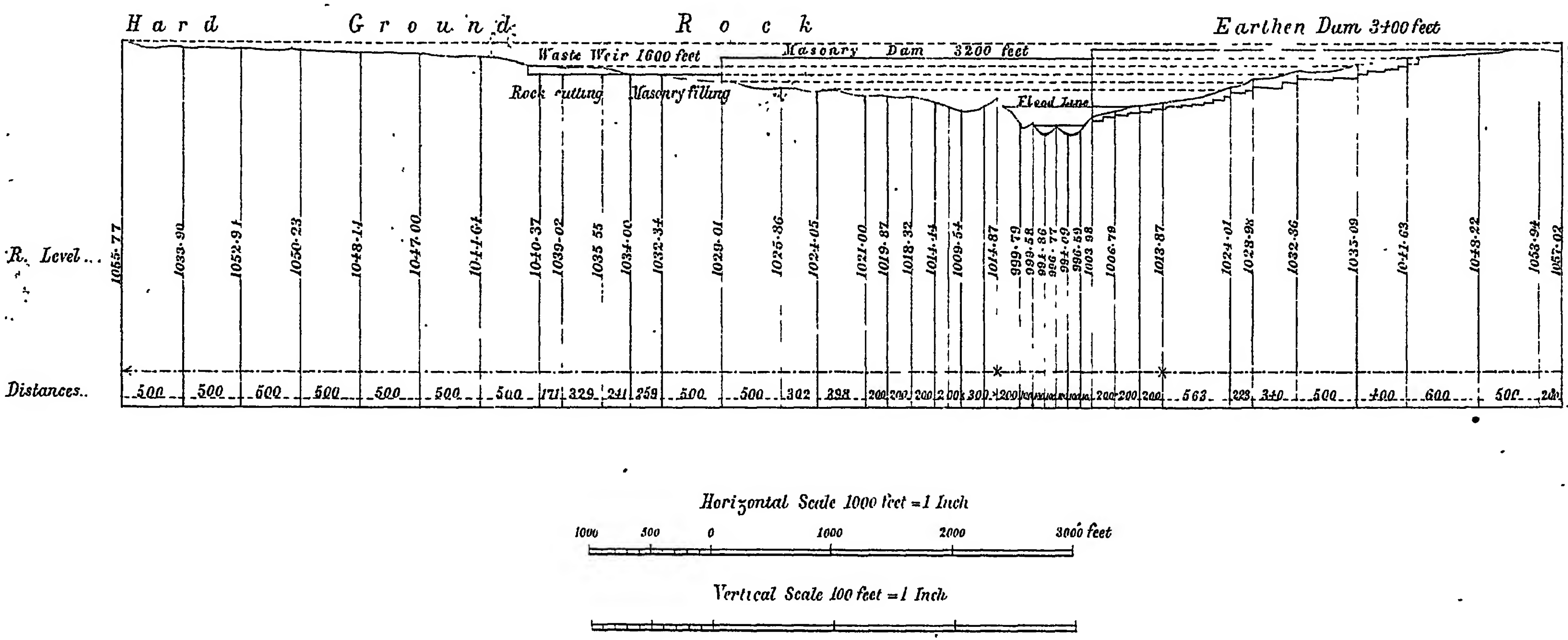
| | Feet. |
|---|---|
| Height of water ... ... | 40 |
| Depth of water flowing over waste weir | 5 |
| Height of masonry dam above flood level ... ... ... | 5 |
| Total height ... | 50 ft. |

and that of the earthen dam 56 feet above the bed of the river in the deepest portion, *i.e.*, 16 feet above high water mark. The length of earthen dam with core wall will be 3,400 feet.

# TORI IRRIGATION PROJECT

*Longitudinal Section*

*On line of Proposed Dam*



**Areas of the lake at different contours.**

The areas of the reservoir for different contours is as follows :—

| Contours. | | Square feet. Area. | Square miles. Area. | Fraction of Catchment Area. | Equivalent in Acres. |
|---|---|---|---|---|---|
| At 45 feet | ... | 245,283,225 | 8·78 | 1/36 | 5,631 |
| 40 „ | ... | 182,556,825 | 6·53 | 1/49 | 4,191 |
| 35 „ | ... | 122,372,325 | 4·38 | 1/73 | 2,809 |
| 30 „ | ... | 78,800,075 | 2·82 | 1/114 | 1,809 |
| 20 „ | ... | 23,880,480 | 0·85 | 1/376 | 548 |
| 10 „ | ... | 3,428,650 | 0·12 | 1/2666 | 78 |

The quantity of water which will be contained in the lake at the level of the waste weir, which is at a level of 40 feet above the bed of the river at the gorge, is 1,753,538,707 cubic feet, or say 1,753 millions cubic feet.

The quantity which passed down the river during August and September 1878 was 1,205,205,696 cubic feet exclusive of floods. After September the stream entirely ceased to flow, but in ordinary years it continues longer.

**Contents of the reservoir at different contours.**

The capacity of the reservoir calculated from cross sections and contours, the details of which are in the Executive Engineer's Office, is as follows :—

| Contour. | | Cubic feet. | | | | |
|---|---|---|---|---|---|---|
| At 40 feet | ... | 1,753,538,707 | cubic feet, | or say | 1,753 | millions. |
| 35 „ | ... | 991,215,832 | „ | „ | 991 | „ |
| 30 „ | ... | 849,613,570 | „ | „ | 850 | „ |
| 20 „ | ... | 523,832,293 | „ | „ | 524 | „ |
| 10 „ | ... | 10,354,523 | „ | „ | 10 | „ |

**Quantity of water available from the drainage area.**

The quantity of water available from the area of 320 square miles is 5,947,392,000 cubic feet,* say about 5,947 millions cubic feet, or more than 3½ times the quantity required to fill the reservoir.

**Loss by evaporation.**

The usual allowance for evaporation and loss from other causes is found from experiment in the Jeypore State to be about six feet of the upper depth of the tank per year. As this water would be mostly used for the rubbee irrigation, this seems to be too much to deduct, however allowing that the whole of the top five feet contour is thus absorbed; this is equivalent to a quantity of 762,322,875 cubic feet, or say 762 millions a year.

**Loss from the amount of water remaining in the bed of the reservoir.**

Also the water in the lake up to the level of 10 feet contour is 10,354,523 cubic feet, or say ten millions, which may also be considered as not available. After the allowance for evaporation, &c.,

* Inches of rainfall × 3,630 = cubic feet per acre . ∴ 8″ × 3,630 = 29,040 = cubic feet per acre.
320 square miles × 640 acres × 29,040 = 5,947,392,000, say 5,947 millions cubic feet nearly.

the balance available for irrigation would be 980,861,309 cubic feet,* say 980 millions. The water which flows after the rains in the nullah is not included in these calculations and would be so much extra.

**Quantity of water required each season.**

There are about 73 square miles of good cultivable land below the dam available for irrigation, out of which about 36 square miles lie in the Tonk territory. Assume 80 square miles to be taken as really fit for irrigation, it is proposed to calculate for a discharge of over 80 or 85 cubic feet per second. This would be sufficient for one crop generally extending over four months. If all is not used, there will remain a balance for the next year's supply.

"Taking as the standard of calculation that one cubic foot per second is capable of irrigating 296 acres, and that land is considered highly irrigated if ⅓rd of the ground within influence of canal irrigation annually takes water, we may consider that one cubic foot per second suffices for the irrigational requirements of 888 acres, or in other words that ·73 *cubic feet per second will* give the required irrigation for one square mile of country."—(*Notes from Forbes' report on proposed canals in Oude, &c.*)

In the present project one cubic foot per second is assumed as necessary for each square mile of country, and ⅓rd of 80 square miles would represent 17,066 acres as actually irrigated.†

**Quantity of water which is required for irrigation.**

The quantity required to keep a discharge of 85 cubic feet per second for four months is 881 millions cubic feet.‡

**Total quantity of water to be provided.**

| | |
|---|---|
| Since the quantity of water required each season to keep a discharge of 85 cubic feet a second during four months ... | =881,280,000 c. ft. |
| Lost in the bed of the tank to 10 feet contour ... | =10,354,523 ,, |
| Loss by evaporation taking upper 5 feet in depth ... | =762,322,875 ,, |
| Total quantity required... | 1,653,957,398 ,, |

| | | Millions c. ft. |
|---|---|---|
| * Total contents ... ... | | 1,753 |
| *Deduct* | | |
| For evaporation ... ... | 762 | |
| Quantity below 10 feet contour ... | 10 | 772 |
| Balance available ... | | 981 millions. |

† Sq. m. acres acres.
80 × 640 = 51,200, taking ⅓rd as actually irrigated = 17,066

‡ Months, days, hours, m., sec., c. ft.
4 × 30 × 24 × 60 × 60 × 85 = 881,280,000 cubic ft.

or say 1,654 millions cubic feet will be required annually.

**Balance in tank at end of irrigating season.**

As the quantity of water available in the tank is 1,753,538,707 cubic feet, the balance at the end of the irrigating season will be 1,753,538,707—1,653,957,398=99,581,309, or say 99½ millions cubic feet.

**Balance to be given by the Rains.**

This will leave a balance to be provided by the next rains of 1,653,957,398 — 99,581,309 = 1,554,376,089 cubic feet, and about 2 inches of run-off would supply this quantity.*

Even if quite empty at the beginning of the rains, the reservoir would be filled by a rainfall of 7 inches on the whole drainage area† if one-third of it run off.

**Surplus water from the Lake.**

In these calculations no account has been taken of the immense volume of water which would be contained over the surface of the reservoir, when the water rises on the weir.

If the water stood
3 feet deep it would
represent about ... 502 millions cubic feet.
4 feet " " ... 730 " "
5 feet " " ... 912 " "

This is exclusive of increased area as the water rises; the actual area at 45 feet contour is found to be 8·78 miles, and 5 feet water on a mean between 8·78 and 6·53 represents a volume of about 1,058½ millions cubic feet. Adding this amount to the contents of Reservoir ... 1,753½
1,058½

would represent a total
volume of ... ... 2,812 millions cub. ft.

* Since one inch of rain on 320 square miles would represent amount of water
128,463,667,200 square inches × 1″ = 128,463,667,200 cubic inches = 713,424,000 cubic feet.
The number of inches that would yield the quantity necessary to replenish the tank for the full supply $\frac{1,554,376,089}{743,424,000} = 2·09$ inches.

† To find quantity of rainfall run-off required to fill reservoir

| Rainfall. | | Sq. miles. | | Acres. | | Contents, reservoir. |
|---|---|---|---|---|---|---|
| X | × | 3,630 | × 320 | × | 640 = | 1,753,538,707 cubic feet. |

$$X = \frac{1,753,538,707}{743,424,000} = 2·3.$$

And if one-third of the actual rainfall is taken as running off the catchment area—a rainfall of 6·9 ought to be sufficient to fill the reservoir.

The largest quantity of rain expected is 8 inches run off, or 5,947 millions cubic feet. 5,947 — 2,812 = 3,095 millions, which may perhaps under very favorable circumstances run to waste.

This perhaps would more correctly represent the greatest amount of water, which would pass over the waste weir than what has been taken, but it is well to be on the safe side.

**Waste Weir.**

A waste weir to discharge 65,883 cubic feet per second, flowing over weir 6·17 feet deep, will be 1,600 feet in length, and there could scarcely be a place better suited for it than the southern end of the masonry dam where the water flowing over the natural rocky surface of ground throughout the entire length, will do no damage.

* However, as the water will have been escaping all the while, the flood line will not rise above 5 feet.

**Materials.**

Before describing the various works which will be constructed in connection with this project, it is necessary to give some idea of the different materials which are obtainable, and the nature of the soil, stone, lime, wood, &c., which are all procurable within a short distance. The specification for the work can be seen in the Executive Engineer's Office, and need not be detailed here.

**Stone.**

Excellent stone, fit for building purposes, can be obtained from the Tori Hill, within a mile of the site of the dam; it can be procured in any size, being hard, compact, and durable.

Good katlas, varying in length from 6 to 3 feet, in thickness from 3 to 12 inches, and in breadth from 12 to 24 inches, can be obtained plentifully within a short distance.

**Lime.**

Good kunkur for lime is procurable in any quantity, near the village of Khera, at a distance of about a mile from the site.

**Wood.**

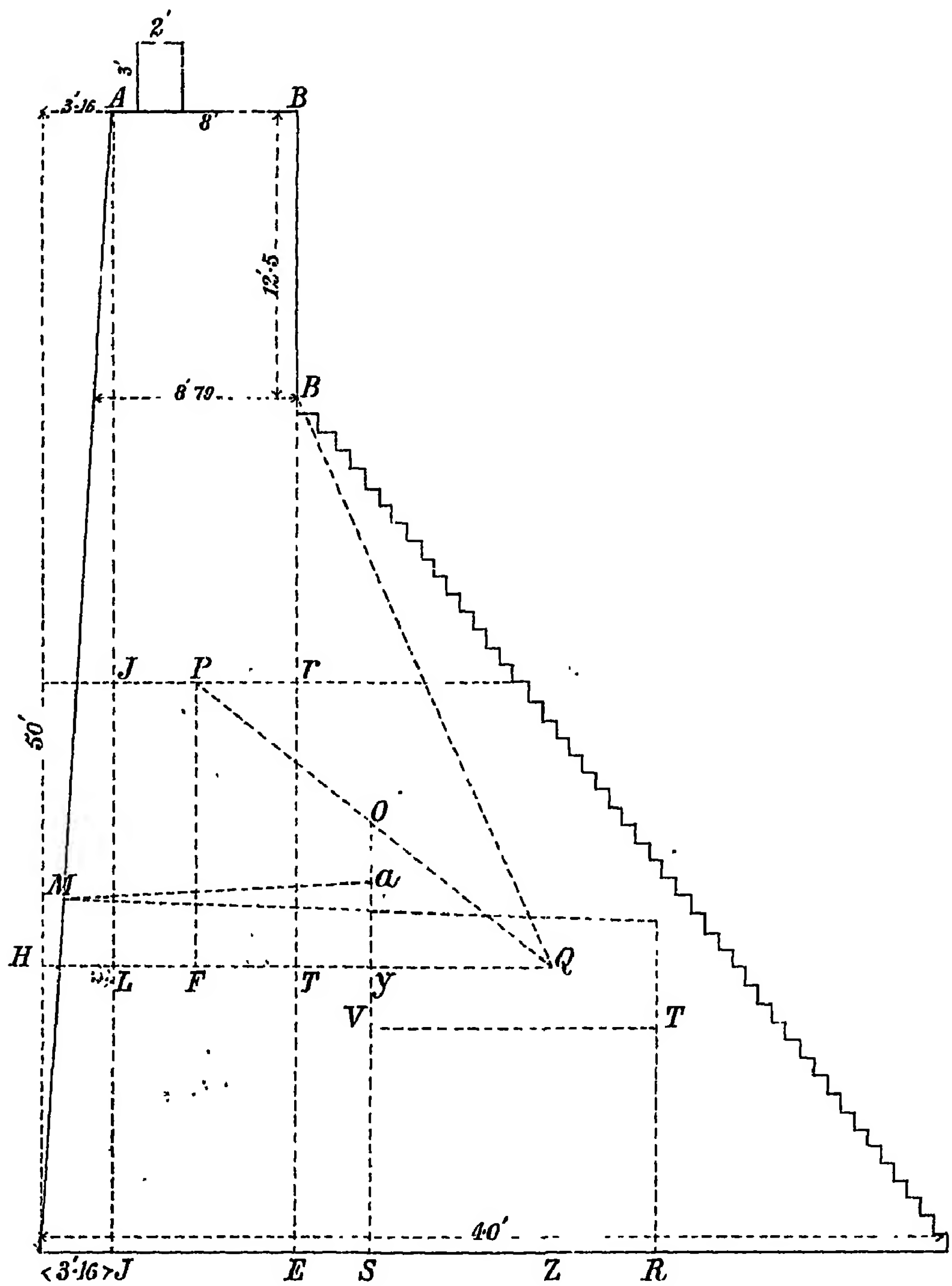
No other wood than Imlee, Neem and Babool is to be obtained, but fuel consisting of dhouk, cheela and chilul, &c., fit for burning lime, can be had abundantly.

**Nature of the Soil.**

The soil through which the canal will be excavated consists mostly of hard black clay, throughout its entire length, very well suited for the rich crops of rice, sugar-cane, opium, indigo, wheat, &c., which one meets with at every village about here.

* For calculations, see records in the Ex.-Engineer's Office.

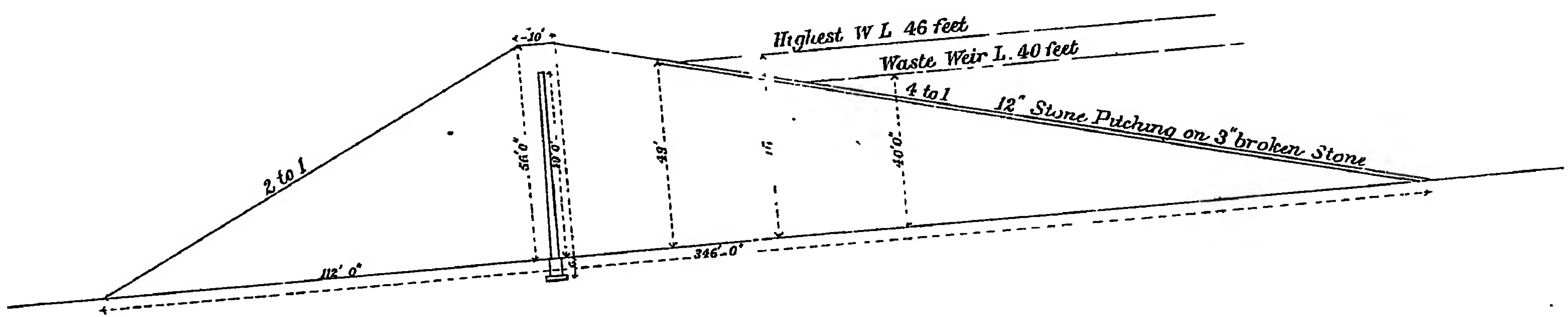
PROPOSED SECTION OF MASONRY DAM




Scale 8 Feet = 1 Inch

# TORI IRRIGATION PROJECT

*Cross Section of the Earthen Dam at its greatest depth*




*Scale 40 Feet = 1 Inch*

In the Jeypore State there are 17 villages, of which 9 are kalsa, which can be irrigated by this scheme* representing areas as follows :—

| | | |
|---|---|---|
| Kalsa | ... | ... 14,000 acres. |
| Jaghir | ... | ... 9,916 „ |
| | Total | ... 23,916 „ |

Besides this there are 18 villages in the Tonk State, which could be irrigated.

It is doubtful if all this land could be taken up at present as the population is not large; still if water is provided, the population is sure to increase. In calculating the probable returns, it is only assumed that 14,000† acres will be actually irrigated. It has been already shown, however, that there will be water sufficient to irrigate 17,066 acres for four months. Even if only 8,000 acres are irrigated, the percentage of profit on outlay would be about 10·8, and there would be ample water then for two years.

This is a fact which should be borne in mind. As Rajputana has suffered from want of water, and a reservoir of this capacity would prove of immense value should such scarcity occur again.

## SECTION 2.—THE DAM.

**General Description.**

On the opposite page will be seen a section of the proposed masonry dam. The letters refer to calculations made in the manuscript copy of the report in the Executive Engineer's Office at Jeypore, which can be referred to if necessary.

The general dimensions have been stated on page 3. Steps will be provided at intervals, and "murwas" along the inner face of the masonry dam.

The earthen dam will be 3,400 feet long, and 56 feet high from the bed of the river, and 41 feet high in the deepest portion. The earth work on the outer face to have a slope of 2 to 1, and the inner face 4 to 1. This face is to be pitched with stone 12 inches deep, and the outside is to be turfed. Below the stone pitching a layer of ballast should be laid to prevent "guttering" of the surface below.

Trial pits were dug along the north portion of the proposed line of dam, but as no rock was found, a pucca masonry corewall will be built in the body of the earthen dam joining the masonry

* See Appendix A.
† See page 14.

dam with wing walls, in height regulated by the slope of the earth work on both faces. The height of the corewall to be three feet above the highest flood level, and the foundation to be every where six feet below the natural ground line.

A detailed account of the manner in which the dam will be constructed, and the materials that will be used in it, will be found in the specification. The necessary thickness of the masonry dam has been calculated by Rankine's formula, limiting the position of the centre of pressure at the base to one-sixth of its thickness from the centre.

**Main Sluice and Tunnel.**

The outlet from the lake into the supply tank will be through tunnels passing under the dam near the south bank of the nullah, all on solid rock, one at 10 feet, and the other 20 feet above the bed of the river, and will consist of 8 circular sluices, each 2 feet in diameter; 4 placed horizontally at 20 feet above the bed of nullah for the high level canal, and 4 similarly placed 10 feet lower for the low level canal.

These are each capable of discharging
with 10 feet head =49·29 c.ft. per second.
5 " " =34·78 " " "
1 " " =15·6 " " "

They will be fitted with cut stone pipes, 1 foot thick, through which the water will pass and fall on to rock. The sluices will be fitted with gun metal faces and vertical iron rods, working in screw heads at the top of the dam to enable them to be easily raised or lowered. The drawings in the Executive Engineer's Office show all details of the sluices and the arrangement of the pipes and screw valves.

---

## SECTION 3.—CANAL.

**Capacity and Section.**

As there are about 80 square miles of land below the dam fit for irrigation, and the quantity of water available from the lake is sufficient to irrigate 17,066 acres, allowing 1 cubic foot per second per square mile of country commanded, the canal is designed with bottom breadth 10 feet, side slopes 1 to 1, and depth of water 3 feet, and with a slope in the bed of 2·5 feet per mile (5,000 feet) and is capable of discharging 116 cubic feet per second. It is proposed to run two lines of canals on the right bank of the river to a length of 20 miles; one a high level at 20 feet, and the other low level at 10 feet above the bed of the river, both of these canals will command all the land available for irrigation, without

any great loss of water. The quantity of water remaining in the bed of the reservoir is only 10,354,523 cubic feet, or about $\frac{1}{170}$th of the whole contents of the lake, which is not so valuable as the greater command of the country which will be obtained by a higher level.

The quantity of water contained in the lake above the 20 feet contour is so large 1,753—524 =1,229 millions cubic feet, that it is desirable to utilize this in every possible way before much of it is lost by evaporation, and as a large area would be untouched by a low level canal, it has been decided to take a canal also at the 20 feet contour. Both canals could of course be used at the same time until the water fell below 20 feet, and the extra area which could be brought under cultivation by the high level canal alone is about 6,440 acres.

One of the great points in irrigation schemes is to get as large an area as possible under irrigation at the same moment; for to be able to supply water when the season is past is of little use.

The canals are to be so lined out as not to be more than 3 or 4 feet in excavation everywhere at a bed slope of $2\frac{1}{2}$ feet per mile. The side slopes to be 1 to 1. The mean velocity will be 2·98 feet per second.

There are no difficulties in the line of the canals—3 nullahs only would have to be crossed, and these have been provided for in the estimate.

All the village road crossings will be sloped off 1 in 20 for the convenience of wheeled traffic.

The average depth of water below the ground surface in the villages through which the canal would pass, varies from 20 to 30 feet.

---

## SECTION 4.—DISTRIBUTARIES.

**General Line.**

No distributaries have been included here, but they will be taken along the high ridges of ground, so as to be able to irrigate the whole of the land by the natural flow of water, their section to be determined by the demand for irrigation.

Should the Tonk Durbar wish at any time for water from this reservoir, and the Jeypore Durbar be able and willing to meet their wish, it would be easy to supply water into the canal passing down to the Tonk territory, by fixing a gauge in the canal where it enters the foreign district, and two Mohurirs, one from the Tonk, and the other from the Jeypore State, could be appoint-

ed to remain there for registering the daily discharge over the gauge of the canal during the irrigating season.

The water could then be paid for by measurement, in a lump sum, at whatever had been previously agreed upon between the two States.

The Tonk Durbar would, of course, make all its own arrangements as to distribution of water and revenue derived from it.

**Villages which can be irrigated and lie in Jeypore Estate.**

Statement A, page 16, shews the names of villages which can be irrigated from this lake.

## PART II.—FINANCIAL.

This subject will naturally be divided into cost and revenue.

### COST.

**General Abstract of Cost.**

The cost of the project, as detailed in the estimates, is Rs. 5,34,749, allowing contingencies at the rate of 10 per cent.; this includes high and low level canals, each 20 miles in length, and compensation for houses and wells submerged.

*General Abstract.*

| Name of Work. | | Cost. |
|---|---|---|
| | | Rs. |
| Excavating Foundation... | ... | 4,418 |
| Concrete for Foundation | ... | 16,267 |
| Pucca Rubble Work | ... | 2,65,969 |
| Earthwork to Earthen Dam | ... | 34,005 |
| Pitching with Stone ... | ... | 5,971 |
| Turfing ... | ... | 3,710 |
| Dry-packing Stones ... | ... | 1,800 |
| Excavating Channel ... | ... | 47,308 |
| Iron Troughs ... ... | ... | 9,000 |
| Iron Posts ... | ... | 7,500 |
| Outlet Cut Stone Pipes ... | ... | 8,640 |
| Katla Stops ... ... | ... | 51 |
| Iron Screw Valves ... | ... | 9,000 |
| Stone Murwas ... | ... | 3,016 |
| Stone Water Gauge ... | ... | 275 |
| Rock-cutting for Waste Weir | ... | 45,606 |
| Overseer's Quarters ... | ... | 1,500 |
| Sheds for Work People ... | ... | 1,000 |
| Survey Expenses ... | ... | 2,500 |
| Compensation for Village ... | ... | 6,000 |
| Ditto for Pucca Wells | ... | 12,600 |
| Total, Rs. | | 4,86,136 |
| Contingencies @ 10 per cent. | ... | 48,613 |
| Grand Total, Rs. | | 5,34,749 |

**Value of Water stored per Re. 1.**

The value of the water stored @ 40 feet contour is 3,279 cubic feet per rupee.

**Cost of storing one million cubic feet.**

The cost of storing one million cubic feet of water is Rs. 30·5.*

**Acres irrigated by one million cubic feet.**

One million cubic feet of water will be available for every 15·8 acres† If evaporation is not considered, it will be available for every 8·5 acres. The return per acre from water rent and enhancement of revenue combined has been taken at Rs. 6-12-0, after deducting for maintenance.‡

**Cubic feet water allowed per acre.**

Assuming 14,000 acres, as irrigated, there would be 118,139 cubic feet water for each acre.§

---

## REVENUE.

*(Exclusive of bed of Tank.)*

FIRST.

**Water allowed per acre, and probable returns thereon, by Central Provinces method.**

The duty of water in the Central Provinces is estimated at 200 acres rubbee irrigation for each cubic foot per second. If all the contents of the tank available are utilized for rubbee alone during the four months, we have $4m. \times 30d \times 24h. \times 60m. \times 60s. = 10,368,000$ seconds, and $\frac{980,861,309}{10,368,000} = 94·6$ cubic feet per second, and $94·6 \times 200 = 18,920$ acres which this water could irrigate.

Since Joypore beegah = one-third of an acre ∴ $18,920 \times 3 = 56,760$ beegahs, which might be irrigated.

| | Rs. |
|---|---|
| Taking this @ Rs. 0/8/0 a beegah for water rate, or 56,760 @ Rs. 0/8/0 ... | 28,380 |
| Rs. 2 per beegah for Raj share of produce ... ... ... .. | 1,13,520 |
| Total Receipt ... | 1,41,900 |
| Deduct for maintenance @ Rs. 0/4/0 a beegah ... .. .. .. | 14,190 |
| Total Profit .. | 1,27,710 |

or 534,749 : 100 :: 127,710 : 23·9 per cent. on the estimated outlay.

---

* $\frac{\text{Estimate}}{\text{Contents}}$ ... ... ... ... ... $\frac{534,749}{1,753} = 30·5$

† $\frac{\text{Acres}}{\text{Millions cubic feet}}$ ... ... ... ... ... $\frac{14,000}{891} = 15·8$ or $\frac{14,000}{1,643} = 8.5$

| | | | |
|---|---|---|---|
| ‡ Enhancement of revenue, per acre ... ... ... ... ... | 6 | 0 | 0 |
| Water rate ... ... ... ... ... | 1 | 8 | 0 |
| | 7 | 8 | 0 |
| Deduct for maintenance, per acre ... ... ... ... ... | 0 | 12 | 0 |
| | 6 | 12 | 0 |

§ $\frac{1,653,957,398}{140\ 0} = 118,139$

Say however that only half of this area is cultivated, it would still leave 11·9 per cent. profit on outlay.

SECOND.

By Ajmere method.

Let us also calculate the returns by the method adopted by the Ajmere Irrigation Department, where the total capacity of the reservoir is taken, and 100,000 cubic feet water is allowed for each acre for two harvests, khureef and rubbee; it is also supposed to allow for all loss by evaporation and absorption.

Say 1,743,184,184 cubic feet to be the contents of the tank at the level of waste weir, after deducting what will be lost in the bed of the tank to 10 feet contour. This will be sufficient for 17,432 acres, and taking three beegahs to an acre=52,296 Joypore beegahs.

Say one-third is cultivated, then we have water rate—

| | Rs. |
|---|---|
| Two harvests 17,432 @ Re. 1 .. | 17,432 |
| Raj share @ Rs. 4 per beegah of two harvests .. .. .. | 69,728 |
| Total Receipt .. | 87,160 |
| Deduct for maintenance @ Rs. 0-8-0 per beegah .. .. .. | 8,716 |
| Total Profit .. | 78,444 |

or 534,749 : 100 :: 78,444 : 14·66=14·66 per cent. on the estimated cost.

THIRD.

Another method.

The area of the land below the dam which can be irrigated is 100 square miles, of which 71·10 square miles as per Statement A, are supposed to be fit for irrigation. Let us take 70 square miles, and allow 200 acres in each square mile, as what will be actually irrigated, *i. e.*, about one-third only; two-thirds being considered unirrigable on account of nullahs, villages, &c. Then 70 miles × 200 acres=14,000 acres=42,000 beegahs.

| | |
|---|---|
| Water rate of 42,000 beegahs @ Rs. 0-8-0 per beegah the least .. | 21,000 |
| Raj share @ Rs. 2 per beegah .. | 84,000 |
| Total Rs. .. | 1,05,000 |
| Deduct 0-4-0 per beegah for annual maintenance .. .. | 10,500 |
| This leaves total profit of Rs. | 94,500 |

which gives about 17·67 per cent. on the estimated outlay. This may not be obtained for a few years, but eventually may be exceeded.

From this it appears that the probable returns, if calculated as in (1), would be 11·9 per cent.

| | | |
|---|---|---|
| (2) | 11 66 | „ |
| (3) | 1. 67 | „ |

If cultivators are encouraged by good government, security, and justice, I think these returns would probably be exceeded, as 8 annas per beegah is not a high water rate by any means.

By the formation of this reservoir only one village, Khera, consisting of 41 pucca and kutcha houses would be submerged, when the water stands at the 40 feet contour or level of waste weir Also 126 pucca wells would be under water. Compensation for these villages and wells has been taken in the estimate.

Detail of area submerged.

The area submerged will be as follows :—

| | | |
|---|---|---|
| Jagheer lands | 2,333 | beegahs. |
| Khalsa „ | 321 | „ |
| Total | 2,654 | „ |

bearing single and double crops.

The details may be seen in the Executive Engineer's Office. Compensation has not been taken for these lands, as the owners would doubtless be provided for below the reservoir, if necessary.

The surveys of this project were made by Sub-Overseer Banarsee Dass, and the greater part of the estimate and report were prepared by Pundit Ghasee Ram, Assistant Engineer.

All the plans and detailed calculations can be seen, if necessary, in the Office of the Executive Engineer, Jeypore.

S. S. JACOB, MAJOR,
*Executive Engineer.*

JEYPORE,
22*nd May* 1879.

## Appendix A.

*STATEMENT shewing the villages of the Jeypore State which can be irrigated from this Lake.*

| No. | Name of Village. | Nomination. | | No. of Beegahs. | |
|---|---|---|---|---|---|
| | | Khalsa. | Jagheer. | Khalsa. | Jagheer. |
| 1 | Tori ... ... ... | ...... | 1 | ...... | ...... |
| 2 | Raipura ... ... ... | ...... | 1 | ...... | 1,500 |
| 3 | Doongri ... ... ... | 1 | ...... | 1,500 | ...... |
| 4 | Kerwara ... ... ... | ...... | 1 | ...... | 6,600 |
| 5 | Bhawulpur ... ... ... | 1 | ...... | ...... | ...... |
| 6 | Deola ... .. ... | 1 | ...... | ...... | ...... |
| 7 | Duogopur ... ... ... | ...... | 1 | ...... | ...... |
| 8 | Manda ... ... ... | ...... | 1 | ...... | 3,000 |
| 9 | Thalandee ... ... ... | ...... | 1 | ...... | ...... |
| 10 | Aliari ... ... ... | ...... | 1 | ...... | 6,375 |
| 11 | Hoondel ... ... ... | 1 | ...... | 1,000 | ...... |
| 12 | Hamirpur ... ... ... | ...... | 1 | ...... | 13,775 |
| 13 | Khawara ... ... ... | 1 | ..... | 4,950 | ...... |
| 14 | Indokia ... ... ... | 1 | ...... | 4,125 | ...... |
| 15 | Chuli ... ... ... | 1 | ...... | 12,850 | ...... |
| 16 | Keoria ... ... ... | 1 | ...... | 12,475 | ...... |
| 17 | Barwas ... ... ... | 1 | ...... | 5,100 | ...... |
| | | 9 | 8 | 42,000 | 29,750 |

42,000 + 29,750 = 71,750 pucca beegahs.
= 23,917 acres.
= 37·3 square miles.

Exclusive of land in Tonk State.